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CIVIC SCIENCE IN THE HOME

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The home offers us a variety of activities which help in the best development of body and mind.

CIVIC SCIENCE
IN THE HOME

BY

GEORGE W. HUNTER, PH.D.
PROFESSOR OF BIOLOGY, KNOX COLLEGE, GALESBURG, ILLINOIS
FORMERLY HEAD OF DEPARTMENT OF BIOLOGY, DEWITT
CLINTON HIGH SCHOOL, NEW YORK

AND

WALTER G. WHITMAN, A.M.
EDITOR, GENERAL SCIENCE QUARTERLY
PHYSICAL SCIENCE DEPARTMENT, STATE NORMAL SCHOOL
SALEM, MASSACHUSETTS

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H.-W. CIV. SCI. IN HOME

W. P. I

FOREWORD TO THE TEACHER

Man's place in relation to science. — Living things, man included, live in an environment which is made up of certain definite factors, and with these factors living things react and interact. Some of these factors are materials — things; other factors are forces. The ultimate result of the complex we call life is the interaction of the materials and forces with the living things on the earth. Man, however, is supreme among animals because of all the animals he alone can control the factors of his environment. He has control of fire and water and electricity. His home has evolved from the cave of primitive man to the complex housing systems of the present age. His communal life has brought with it new problems — the disposal of wastes, the safeguarding of water and milk supplies, the need of community sanitation and hygiene. His higher civilization demands use of machines, the need of which his forefathers neither knew nor felt; of transportation and communication; of more varied and practical education as well.

Children's interests in science. — In the midst of such a life as this our children are growing up. Science beckons to them from every side. In every device used at home for comfort and better living, science speaks. The telephone and telegraph, the trolley and the automobile, the airplane and submarine, have all become part and parcel of their daily lives. Many of the common things of science which directly affect the lives of children are equally interesting to both sexes. But in any scheme of modern education we must take individual differences into consideration. We no longer educate in the mass. Sex, age, environment, capability, heredity, all are important factors which must be recognized by the modern teacher as having a place in educational practice as well as theory.

The project method. — Since we must allow for individual differences in our scheme of education, it goes without saying that mass education, which does not account the child as a personality, can no longer be admitted as a part of our scheme. We must take cognizance of all the factors mentioned in the last paragraph; environment, age, and sex act more uniformly and thus may be taken into account in the forming of classes or groups. But individual capability and endowments, heredity's part in the game of life, are much more difficult factors with which to deal. Recent developments in educational psychology show that one method of attack, however, has certain elements which may be used successfully with any group of children not too young to think to a conclusion. Problem solving of one sort or another is common to all the activities of life. It is the one great factor which goes toward making for success or failure in life. It should be part of the mental attitude of every educated person. Problem or project, call it what you will, represents the method by which things worth while in life are achieved. It offers the pupil a method for accomplishing those things in life which mark off greatness from mediocrity — the leader from the led.

Methods in science adapted for children. — We hear a good deal nowadays about the logical versus the psychological approach. No teacher, and the word is used in its truest sense, can teach except from the viewpoint of the child. Approached from this angle, the psychological becomes logical. We must have a plan, but we must remember that a plan may sometimes be changed to advantage. Above all we must be human. If we but remember how we looked at things with the eyes of thirteen instead of those of forty-three we will have no difficulty in solving the method of lesson attack. We must remember, too, that concepts *grow* and are not always brought to maturity in one lesson. The cyclic treatment of topics, which has been followed in Civic Science, is a far more natural method of

acquiring information than a dogmatic statement, made perhaps with proof but dimly comprehended and soon forgotten.

The textbook in introductory science. — Any book in introductory science should be based on the facts we have just mentioned. It must contain an adequate amount of the basic material from which the interpretation of the common things of interest in life may be gained, and it must also be adapted to start the individual boy or girl whose interest has been awakened along the line of the project in which this developing interest would naturally flow. Most of all a textbook should interpret to the child the part played by the various natural factors in his environment. It should conceive the child as the center, and all the world of the child revolving around this center. In this conception boys and girls would first become aware of the vital part played by air, water, light, heat, and food on them as individuals within their homes. This much is common to all — the application of certain of the general facts learned could then be carried out as special projects by various pupils interested. After the child has learned the meaning of these central factors in the home, the next step would logically be the application of the forces of nature by man in communal life. In short, Civic Science plans to lead the child in a manner which is both logical and psychological from the simple factors which make up his environment as a living thing to the complex combinations and interactions which have arisen through what we call civilization. It is the interpretation of this complex that Civic Science undertakes with the belief that children, if given a rational point of view, will have enough varied interests to build on the outline which follows. They will thus work toward the solution of those things in science which seem most worth while to them as individuals and most worthy of them as future citizens.

Acknowledgments. — For an incentive to undertake this work, the authors are indebted to those educators who have

written much on the subject of science for young people, particularly, Thomas M. Balliet, Thomas H. Briggs, John Dewey, Charles W. Eliot, David Snedden, George R. Twiss, and John F. Woodhull. To the many science teachers who have been active in developing general science from its early beginnings to its present state, the authors make full acknowledgment for much help and inspiration. Acknowledgment for illustrative material is made in the text. The drawings were nearly all made by Mr. F. M. Wheat, of the George Washington High School, New York. The following teachers have carefully read the entire proof and made many valuable suggestions: Mr. M. C. Leonard, Vice-principal, Dickinson High School, Jersey City; Miss A. P. Hazen, Head of the Department of Biology, Eastern District High School, Brooklyn; and Mr. George C. Wood, Head of the Department of Biology, Commercial High School, Brooklyn; and also Miss Lydia Holtman, Knox College, Galesburg, Ill.

Reference Books

Dewey, *How We Think*, especially Chapters IV, V, VI, and XV. D. C. Heath Company.

Flexner, *A Modern School, New York Occasional Papers No. 3.* General Educational Board, New York.

Hunter, *Laboratory Problems in Civic Biology*, Foreword. American Book Company.

Huxley, *Physiography.* Appleton Company.

Snedden, *Problems of Secondary Education*, Chapter XXI, Houghton Mifflin Company.

Trafton, *The Teaching of Science in the Elementary School*, especially Chapter V. Houghton Mifflin Company.

Twiss, *Science Teaching*, especially Chapters II, III, IV, and XIX. The Macmillan Company.

Woodhull, *The Teaching of Science.* The Macmillan Company.

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PART I. THE HOME AND ITS ENVIRONMENT

CHAPTER I

WHY WE STUDY SCIENCE

Problems. — 1. *Why is some knowledge of science essential to us?*

2. *Why is the "method of science" important?*

3. *What is a science project?*

Living in an age of science. — Do you ever stop to think you are living at a time when science has done more to make everyday life comfortable than at any other time in the world's history? You sleep at night in a bed, the springs and parts of which were made by machinery, and the covers of which were woven by a complicated process; you wash with soap made by chemical processes; you eat prepared breakfast foods, and cook on a gas, coal, or wood stove. You eat in machine-pressed dishes; ride to school on electric cars, or trains, or automobiles, the parts of which were made by machines. Every part of your waking and sleeping hours you come in contact in some way with devices which involve a knowledge of science, and yet how few actually know very much about the science which underlies all these useful and beneficial inventions.

Man's progress in science recent. — Have you ever thought how many things have come into common use since your father and mother were born? X-rays, flash lamps, radium, the pianola, liquid air, submarines, gas engines, sky scrapers, harvesters, vacuum brakes, fireless cookers, vacuum bottles, vacuum cleaners, street cars, airplanes, hydroplanes, motor cycles, gas mantles, automobiles, carpet sweepers, asphalt paving, safety matches, pneumatic appliances, moving pictures, typewriters and adding machines, wireless telegraphy, pneumatic mailing tubes, electric heating and cooking apparatus, turbines, paper towels, electric lighting, reënforced concrete, sanitary drinking fountains and cups, and a great many other things which we have come to

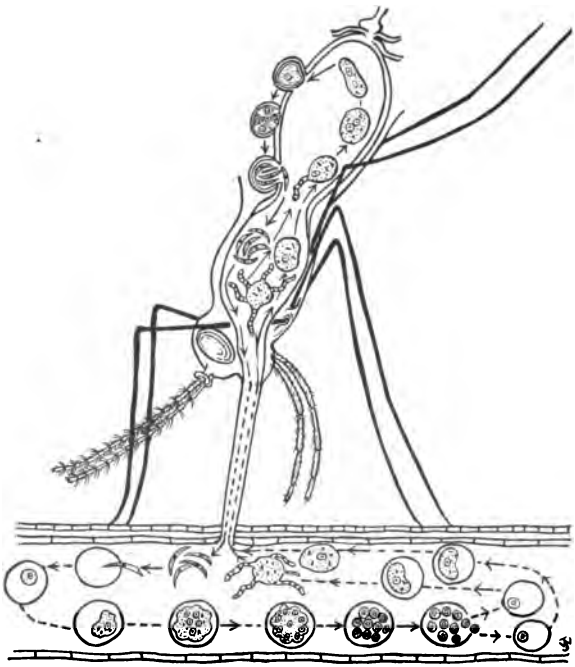
A triumph of modern science. How many scientific inventions can you think of which are probably utilized in this large office building?

look upon as necessities of life. Could any one be considered educated without knowing more than we do about science?

Reasons why we should study science. — Since scientific devices are used so much in and about our homes, we ought to have at least some practical knowledge of the common things in science, so that we may know how to help solve the problems that come to us. With a little knowledge, we can fix leaking faucets; we can find out why the electric bell does not ring; we can explain why the ice box is not preserving food properly or why the bread does not rise. Some day we shall be called upon to earn our own living. Opportunities for promotion in many fields of work will be small for those who do not understand common things in science. The practical machinist who can apply his knowledge of the principles of science to the working of his machine is the foreman in the shop. Then too, our health depends in a measure upon the knowledge of science. It used to be thought that diseases like diphtheria, for example, were the dispensation of Providence, but nowadays we look nearer for the cause, and find it to be germs.

An example of how the method of science was used in the discovery of malaria. — The Italians thought formerly that malaria was caused by bad air, and hence they called it *mal aria*. The discovery of malaria is an interesting story. It was near the end of the last century that a French physician named Laveran discovered that malaria was probably caused by a tiny parasite which lived in the blood cells of man. He reasoned that this was so because he found the little animal only in the blood cells of those suffering from malaria. A little later an English

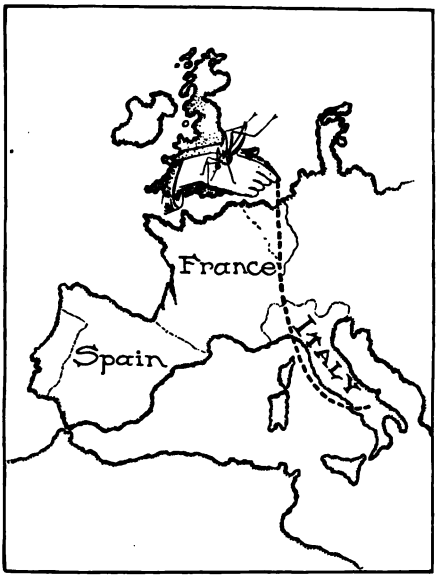
army surgeon named Ross, working in India, found after a long series of experiments, that mosquitoes had something to do with malaria. He knew that they were blood-sucking insects, and that they were always present where malaria



The life history of the malarial parasite. This cut shows parts of the body of the mosquito and of man. The mosquito injects the crescent-shaped bodies into the blood of man. These enter the blood corpuscles, develop spores which, after being released from the corpuscle, form two kinds of cells. These two forms of the parasite are sucked with the blood into the body of the mosquito, where the other part of the life cycle of the parasite takes place.

was frequent. He reasoned that mosquitoes might carry this germ. He worked a long period of time before he found finally that a certain kind of mosquito, called *anopheles*, had some unusually tiny bodies attached to the

inside of their stomachs. These little microscopic bodies were full of black specks. Ross found later that these black specks were only present after a mosquito sucked blood from a person having malaria. By a process of reasoning and experiments, he discovered finally that not only did these mosquitoes carry malaria, but that people could not have malaria unless they were bitten by one of the anopheles mosquitoes, for a malarial parasite has to live a part of its life in the body of the person who has malaria and another part of its life in the body of the mosquito.



The final proof that the mosquito carries malaria.

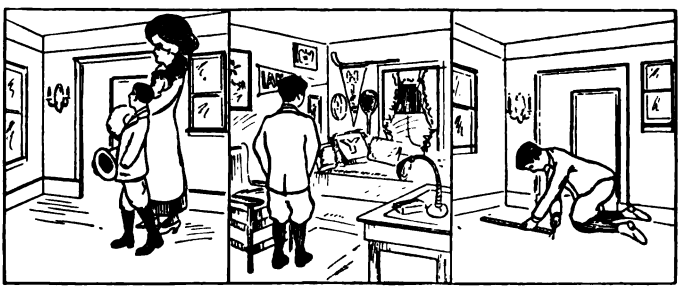
Then came the testing of this remarkable theory in Italy. A number of people who worked in a malarial region, near the city of Salerno, were persuaded to live in houses which had been carefully screened. It was discovered that the malarial mosquito came out only at night. Practically none of the people who stayed in the house at night behind their screens got malaria, although almost all of the people in the immediate neighborhood were suffering from the disease.

The final proof came when two English physicians, Dr. Manson and Dr. Warren, allowed themselves to be bitten in England by mosquitoes which had been sent from Italy, but which had been previously fed on the blood of a person having malaria. Neither of these men had had malaria previously, but eighteen days after they were bitten, they both came down with the disease. This is an excellent example of how scientific method is applied in the discovery of new facts important to mankind. All we have to do to escape malaria is to be sure that malarial mosquitoes do not bite us.

A study of the method of science. — If we study this scientific method more fully, we find, first, that the scientist has a reason for trying to solve a problem. He thinks over this problem, and finally gets clear in his mind just what he wants to find out. He has then fixed his *problem.* His next step is to try to find out some *method* or methods of solving it. This he does by thinking over various ways in which he can attack it. He finally fixes on some method which he tries out by means of *experiments* to test whether his theories are correct. He may and often does have to perform hundreds of experiments before he is satisfied that he has a correct solution. This was the case with Dr. Ross as he worked over his problem of how the malarial mosquito played a part in giving the disease to people. At length, after he has satisfied himself that he has the solution to his problem, he must then put it to a practical *test.* This was done, you remember, by the English doctors who allowed themselves to be bitten by the mosquitoes, and thus proved that mosquitoes transmit malaria.

The method of science useful in daily life. — This method of science which we have just described should become a

part of the daily life of every educated person. It should become a habit of mind, a way of thinking. Scatter-brained people may think; we find, in fact, that we think when we daydream, but we do not organize our thoughts, nor do we put them to any use. Science was once called by a great scientist, "organized common sense," and such it really is. Nowadays too many people reason from statements heard which they want to be true. They have



We estimate, we compare, we verify in the method of science and in everyday life.

heard only one side, and do not care to know any other. Bolsheviki are good examples of such people. People who can think straight are the ones who succeed in life. A dangerous attitude of mind results from careless, wrong modes of thinking.

How the method of science is used in straight thinking. — When we think properly, we are using some steps that the scientist uses when he plans to work out his problem. Take, for example, any question in your daily life that comes to you. It comes in the form of a problem. Your father has rented a new house. Your mother has promised you a room of your own, and a new rug for it. You are visiting the house. You look at the room, and try to make up your mind as to its size. You think it is about ten feet by twelve

feet, and therefore you will want a rug not larger than eight feet by ten feet. You have *estimated* the size, but you may be wrong. You *compare* it with some room with which you are familiar in your own house. Yes, it seems to be about ten feet by twelve feet in size, but you decide it will be better to measure it. So you get a tape measure and you find that you were practically correct. You have *verified* your conclusion. In other words you have followed the method of scientific thought. You have estimated the size, compared it with other rooms, and reached a *conclusion;* you measured it, and found you were correct.

The habit of scientific thinking. — If we use this method at all times we shall acquire a habit of mind that will be very useful in later life. This method teaches us to be accurate in our judgment. It teaches us to observe. It teaches us not to accept a statement without evidence. It teaches us to weigh the evidence, then draw our conclusions and finally to verify our conclusions. This habit of mind is worth much more than any number of facts that this book can give.

How we use this method in our home work. — We get out of life just about what we put into it. Each one of us will get just as much from the method of science in this course as we are willing to work out with enthusiasm. In any event, boys and girls taking a course in general science will get a great deal of valuable information which will be useful during life. Much of the *information* will be found in this book and in other books which are suggested in the reference lists. But the *method* of doing things we must learn outside the reading books. To work out home problems or projects with such simple apparatus as is needed to draw conclusions, is far more profitable than

memorizing any number of facts, for by scientific methods such as these, people make discoveries which are of value to the world.

The project and how it may be worked out. — *You* are the one to plan your own project and work out the problems connected with it. It will not mean so much to you unless you *want* to know about the thing you are trying to do. Books, people, and experiments may all help toward the achievement of your project, but *you* must carry it through yourself. Take, for example, a project to determine the best methods of cleaning a room. This would mean investigation on your part of the construction of brooms, wet and dry dust cloths, dustless dusters, carpet sweepers, vacuum cleaners, and of the methods used in performing the work. Not only should the mechanical working of these devices be understood, but also the amount of time and labor spent in cleaning a room with each must be estimated or measured separately. We would naturally be interested to know also how much this time is worth, and that should go into our estimate of the value of the different methods. But more important is the knowledge of how much dust is raised by each method and the relative number of bacteria which would be stirred about in the air. To understand this it would be necessary for us not only to know something about the bacteria themselves, but also to perform experiments with a series of prepared culture dishes by which we would determine the relative number of bacteria in the air during each method of cleaning. These culture dishes may be obtained from the board of health, or a good laboratory, or a culture medium made and the dishes filled and sterilized in the school laboratory. Eventually you have a series of facts

which enable you to determine which is the best method of cleaning a room. A written report giving all data by which you have reached your conclusions and including interesting facts learned by your study completes your project.

In order that you may be able to choose some one project in which you will be interested, a suggested list of projects follows at this time. These projects will be mentioned again in connection with the chapters with which they are connected. But since projects require planning and often a considerable length of time to work out, you should choose your projects now and begin to plan work on them at once. In this way you will be ready to report to the class at the right time.

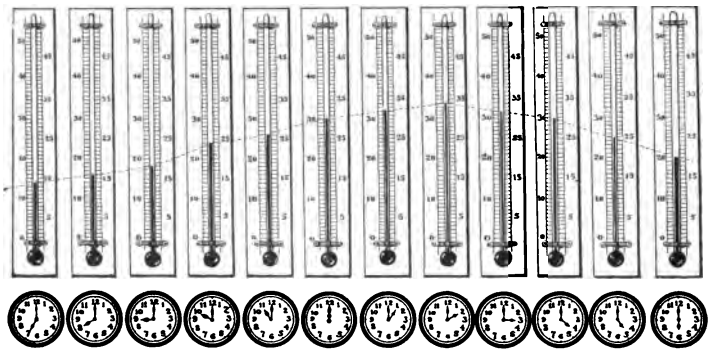
A LIST OF SUGGESTED PROJECTS

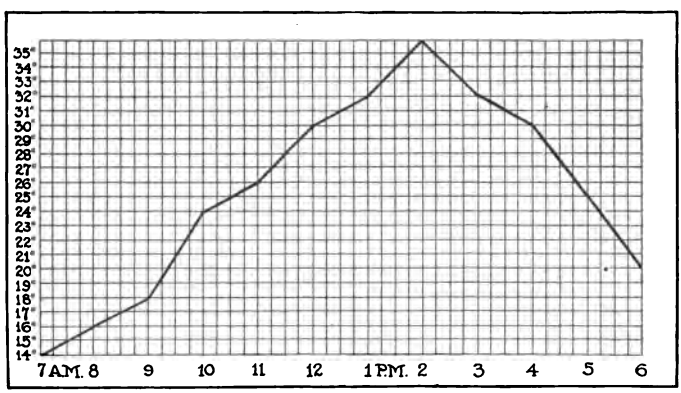
1. To learn the advantages of renting and of owning one's home. Page 24.
2. To make a home laboratory. Page 39.
3. To discover and remedy harmful effects of air about the home. Page 39.
4. To increase my lung capacity. Page 56.
5. To secure pure air in my bedroom. Page 57.
6. To prepare for life saving where artificial respiration must be used. Page 57.
7. To make a lift pump. Page 74.
8. To see how much water is wasted by dripping faucets. Page 74.
9. To see what nutrients are in the foods commonly used in my home. Page 90.
10. To obtain starch from potatoes. Page 90.
11. To plan for economical buying for our family for one week. Page 91.
12. To test and preserve eggs for home use. Page 115.
13. To pasteurize the home milk supply. Page 116.
14. To exterminate flies from my home. Page 131.
15. To prepare myself to keep the house plumbing in order. Page 144.
16. To compare my daily use of time with an ideal plan. Page 158.
17. To form correct health habits. Page 159.
18. To make a house thermometer. Page 175.
19. To qualify as an expert heating device operator in my home. Page 188.

20. To learn how my coal range is constructed and how to run it. Page 189.
21. To remove the fire hazards from my home. Page 205.
22. To find out what my clothes are made of. Page 219.
23. To improve the lighting in my home. Page 238.
24. To remedy any eye defects I may have. Page 253.
25. To plan an ideal house. Page 267.
26. To become a landscape gardener for my own home. Page 286.
27. To learn the soil needs in my garden for any particular crop. Page 297.
28. To eliminate the plant pests from my home grounds. Page 314.
29. To keep the machines of the home in good working condition. Page 331.
30. To install an electric bell in my home. Page 344.
31. To install a night light in my bedroom. Page 359.
32. To understand the mechanism of the piano and the piano player. Page 371.
33. To plan how to utilize the playgrounds of the home lot. Page 390.

Tools with which we will work.—A notebook in which to make careful notes of all work done is an essential part of our equipment. We should always take notes of everything we do, both in the laboratory and at home. These notes should be carefully kept, and drawings made to illustrate them, either with a hard pencil or with a drawing pen. We must learn to use instruments with which to measure. The use of the metric system is best for all scientific measurements, and a knowledge of the metric tables will be found valuable. We must also know how to use a compass and a T-square, and other instruments useful in diagram making. Perhaps the most essential thing of all is to learn the value of accurate figures, as this is needful in the making and understanding of graphs. A graph is the diagrammatic representation of a certain number of figures. An example is seen in the diagram on page 22, in which we are illustrating the changes of temperature which take place during a day. The figures of the thermometers and clock faces show the temperatures at different times during the day and the hours. The figure on the squared paper shows

how the graph is constructed. It is important to learn the making and understanding of simple graphs, as a knowledge of this kind should be part of the equipment





Observe that the graph represents the same temperatures that the thermometer readings show.

of every well-informed boy and girl to-day. Last of all, and perhaps most important, we need *enthusiasm* for our work. Success along any line requires attention, thought, and interest. Interest is valuable in school work

and failure is often due to indifference. Surely in this great world of science about us, there is enough to interest each one of us.

REFERENCE BOOKS

Fall, *Science for Beginners*, Chapters I and II. World Book Company.
Hunter, *A Civic Biology*, Chapter I. American Book Company.
Hunter, *Laboratory Problems in Civic Biology*, Chapter I. American Book Company.
Lee, *Health and Disease* (Advanced), Chapter XV. Little, Brown, and Company.
Ritchie, *A Primer of Sanitation*, Chapter XXIV. World Book Company.
Smith and Jewett, *Introduction to the Study of Science*, Chapter XII. The Macmillan Company.
Winslow, *Healthy Living*, Chapter XXIII. Merrill Company.

CHAPTER II

THE ESSENTIALS OF AN IDEAL HOME

Problems. — 1. *To see how man's idea of home has changed since remote ages.*

2. *To see what our present homes do for us.*
3. *To learn how to secure efficiency in the home.*
4. *To see what a home can contribute to our health.*

Home Laboratory Exercise. — To make out a score card for my own home.

Project I. — RELATIVE ADVANTAGE OF RENTING AND OF BUILDING ONE'S HOUSE.

If your parents are renting a house or apartment, you may be interested to undertake this project.

1. Selection of a desirable home site. Look over the vacant lots available for building in various sections of the town or city. Value of lot? Why selected?

2. From study of magazines (consult library) select suitable house plans. Probable cost? Other expenses to equip the house?

3. How could this house be built? Mortgage. Building loans. Cost of hired money. How much must the owner invest?

4. Compare yearly cost of living in one's own house and in rentals.

What is a home? — To the boy or girl who reads this, home is the place where he or she slept last night, arose this morning to an early breakfast, and then left bright and early so as to be in time for school. A boy probably thinks of the closet in his bedroom, filled with his books

and games, his skates and gun. The girl thinks of her dainty bedroom, with its pretty pictures and hangings, and both probably think more than anything else of the father and mother who make life really worth while at home. Home, then, is more than a place to live in; it means father, mother, brothers, and sisters; it means

A suburban home.

family life, with all its give and take, its unselfishness and loyalty to the ideals which father and mother believe to be right.

How homes have changed from their first beginnings on the earth. — There was a time a good many thousand years ago when people living on the earth had no real homes. They were nomads, traveling from one place to another, staying here a night and there a day, never remaining long in one place. Then came the discovery of fire.

With the fire they warmed the caves; and in consequence people lived in greater comfort and made these caves the first real homes. Then they began to domesticate or tame the wild horses and wilder cattle with which they came in contact and to discover that certain fields of wild grasses were good fodder for their horses and cattle. Later these wild grasses were cultivated and the first cereal crops came into existence for man. Man began to build permanent homes now, because he had food to eat and fire with which to cook. Probably the first of these homes were nothing but tents made of skins, or rude huts, but they were enough for the few needs of primitive men and women. Food and cattle were more abundant in certain places, where water and wood for fire were plentiful. These advantages attracted a number of people who came to live near each other. Mutual protection was gained also, and so we have the beginnings of a town or community. It is a long and far cry from the tiny collection of huts to the modern great city, but our cities and towns of to-day have grown from

Indian tepee. A type of very primitive home.

just such beginnings as we have been talking about in this paragraph.

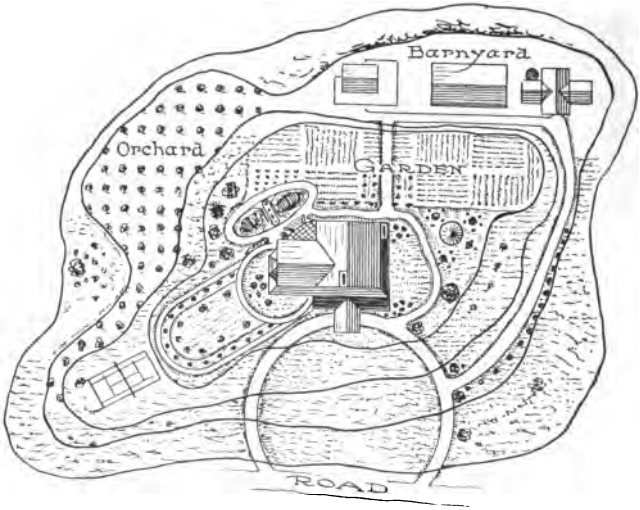
What home life does for us. — Doubtless each one of us thinks of his home as a place for shelter, for food, for material comforts of all kinds, but it should be more than this. The home should be the center of a little group in which absolute loyalty is seen instead of selfishness and individual rights. At the present time this country of ours suffers much because of the lack of team work on the part of all men and women who share its benefits. Real home life should teach us coöperation and unselfishness, not individualism and selfishness.

The home requirements of civilized man. — Man, if he is to be a healthy individual, and if he wishes to remain so, should have the following:

1. Pure air — this means air free from dust and germs, smoke and bad odors.
2. Pure water — water free from all dirt and germs.
3. Good and plentiful food, well taken care of and properly cooked.
4. Moderate heat, both in summer and in winter.
5. Plentiful light, both natural and artificial.
6. Clothing suitable to the time of year.
7. A home well planned, well ventilated, well lighted, with some ground around it for a garden and playground. If the latter is not possible, playgrounds and parks should be provided in the near vicinity.

The ideal home site. — We have already spoken of the detached house being the ideal place in which to live. This is not only because of the air space around it on all sides, making it cooler in summer and giving good ventilation, but also because of the privacy which comes from living

in a house separated from its neighbors. Detached houses are more frequently owned by those who live in them, and this helps to make the owner more thrifty. One is always more careful of a house he owns than of one he rents. Then, too, the garden is indirectly a source of profit as well as of health and pleasure. Many families furnish all



The house in the diagram is ideally located as regards drainage. The irregular lines are contour lines, each representing 5 feet in altitude. Make a diagram in your notebook showing a cross section through house and grounds, indicating differences in elevation.

the vegetables needed during the summer from a small garden, carefully planned and tended.

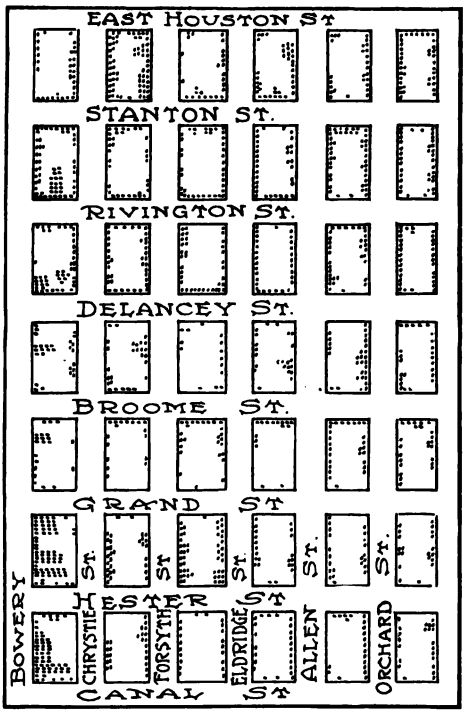
If we live in the city, both light and air are very important factors for our consideration. In most cities nowadays, good laws have been made which require wide air shafts and sufficient window space in all apartments or dwellings. But in many cities in the United States, we still see houses like the one shown in the picture, in a

A congested district.

Compare this detached house with the houses shown in the picture above. In which place would you rather live?

congested district, where neither light nor air is abundant enough for healthy living.

Some ways to work for an ideal home. — No doubt we would all like to live in a home that is ideal. While this is not possible, for no one of us is perfect, yet we can do a great deal to better the conditions under which we live. The following paragraphs will tell us some of the ways in which we may improve our homes.



This map shows how cases of tuberculosis recur in the same houses year after year. Each black dot represents one case of tuberculosis. The region is one of the most densely populated regions in New York. Is it a healthful locality in which to live?

Crowding a menace to health. — Although it is not always easy for us to change the place where we live, yet when we realize that crowding in a big city frequently makes a higher death rate, we should be willing to plan for a better place in which to live. The map shown in the illustration gives ample proof that some crowded conditions help to cause diseases. All of the little dots in the picture represent cases of tuberculosis. Notice how

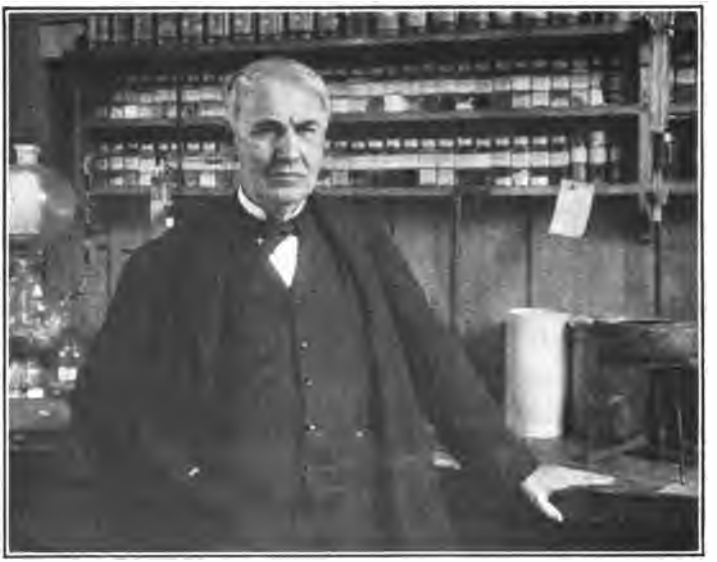
numerous the cases are in certain houses. This may mean that under the crowded conditions in which people lived, the disease was more easily transmitted from one person to another. A small one-family house, if one can afford it, is far better than the crowded apartment or tenement.

Cleanliness a factor in the home. — A large, airy house in a good location is not the only necessity for good health. If houses are kept closed long, or allowed to run down; if they have leaky gas or sewage pipes, or if they are overrun with rats or infested with flies, they are far from being sanitary and healthful. A clean fly may have twenty thousand germs tucked away on its legs or body, while a dirty one may carry several million. We can at least keep our homes clean and free from dirt, and we can also be clean in our own person and clothes.

Carelessness. — Carelessness always plays a big part in making our homes unpleasant places in which to live. There are numerous calamities besides sickness which may come to the home. One of the most treacherous is fire. The fires in the United States average 1500 a day. The cause of a great many of these is a carelessly dropped match, a lighted cigarette, the gas turned on and forgotten, or the electric iron thoughtlessly left, — in other words, carelessness.

What is more valuable than a pair of good eyes? Close your eyes for five minutes, and think what life would be if, instead of five minutes, it was for five years, or for your whole life that you were to be surrounded by darkness. Think of what you would miss in life. Carelessness in caring for eye defects, such as nearsightedness or farsightedness, or careless use of lights and lighting, — all of these things may mean a lessened use later in life, or perhaps loss of use of these important organs.

Efficiency in the home. — Nowadays we frequently hear the word "efficiency." We have efficiency engineers in

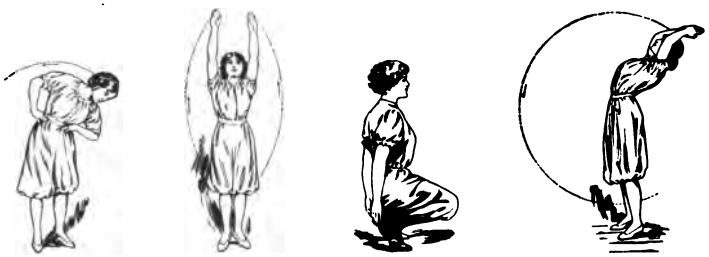


Thomas Edison, one of our greatest inventors.

great manufacturing plants to see that the most is made of the machinery, and the time of the workmen. Why should not each one of us be an efficiency engineer in our own home? We should all train ourselves to discover where there is wasted energy, and then study how to prevent it. In factories machines have largely replaced hand labor. The machines last only a few years, and are then replaced by others which can do the work better. Why not apply this business principle of efficiency to our homes? It would mean more time for recreation, reading, and social life. The reduction of house work and the use of sanitary conveniences would often do much to make the health of the

family better. How is it in your home? Could a few dollars be well spent for equipment which would make mother's life easier? Why not study the situation as a home project?

The habit of work. — The great inventor, Edison, in his seventies, is able now to work long hours day after day. It was his habit to work, even when he was a small boy. We find that most men and women who have developed into leaders accustomed themselves to work when they were young. Learn to accept your share of the home



1 2 3 4

Practice these exercises every morning and evening and watch the effect upon your general development. (After Tolman.)

duties, for thus you will develop a sense of responsibility and habits of industry. Learn to do home tasks willingly, for thus you will develop unselfishness. The efficiency of a household is lowered by every idle member who lives there. Learn now to be a helper, and some day you will assume more easily the responsibilities which will come to you when you are grown up.

Recreation in the home. — It is an old saying that all work and no play makes Jack a dull boy. All work is wrong, and all play is wrong, but play is just as important as work for normal boys and girls. Recreation sometimes means *re-creation*, for we are really made over by doing

interesting things which rest our body and mind. Reading, music, visiting our friends, playing games, are all good types of indoor recreation and outdoor exercise and are absolutely necessary for a growing boy and girl. Our lungs need developing, as do our muscles. Baseball, tennis, walking, hiking, canoeing, camping — all of these have their place, and even if we have no opportunity for these, a little yard space is sufficient for such games as tether-ball, Russian nine-pins, volley ball, or hand ball.

This boy, as a result of exercise, fresh air, and nourishing food, has a strong healthy body. He is able to take care of himself. (After Davison.)

You must obey health rules. — Most of all, daily following the rules of good health will do more than anything else to make your life a happy and a helpful one. Did you ever think what it would mean not to be able to run a foot race, or make a high jump, or play a game of tennis or baseball? Without proper attention to the rules of right living, proper eating, drinking, breathing, and care of your bodily organs, even the strongest of you may become weak. You may be in the best of health now, but if you are not willing to continue the proper care of your body, you may pay the cost later. Do not try to cheat somebody else by not brushing your teeth to-day, or not wearing the warm clothes that mother suggested, or by reading too long in that poor light, for the only one you

are cheating is yourself. Be faithful in your health habits; it pays in the long run.

Scoring the home. — Emerson has said that we must "hitch our wagon to a star." This really means that we must have high ideals in life. In order to estimate your own homes in the light of the chapter you are now reading, there follows a score card which each boy and girl should study, and then for his or her own satisfaction attempt to score his or her own home. Remember to be honest in your scoring, and although your score may seem low, nobody's score will be perfect, because we have "hitched our wagon to a star." This home project will be a preliminary survey of our homes, and in a later chapter, we shall make a more careful study under each of the headings in this score card. You will notice that this first score card has three columns headed respectively, "Perfect score," "My first (guess) score" and "My final (real) score." This means that you are to make an outline of this score card as a preliminary exercise for your notebook. In the second column place the score you think you ought to have, after having first consulted the score cards you are referred to at the ends of certain of the chapters. The scores should be totaled and a grand total obtained. The third column marked "My final (real) score" will be filled little by little as you study the future chapters. You will probably find that your first estimate was far too high and thus the third column will serve to check up on your "guess" or first estimate. This shows a use of the scientific method referred to in the first chapter, and will be excellent practice for you.

The score card that is given is only a suggestion and may be advantageously changed to meet local conditions.

HOME SCORE CARD

	Perfect Score	My First (Guess) Score	My Final (Real) Score
1. Environment			
Pure air	10		
Pure water	10		
Well-drained soil	10		
Plenty of sunlight	5		
Not too great extremes of heat or cold	5		
Foods supplied from home garden	5		
Foods cheap and good	5		
2. Water in My Home			
Safe supply	10		
Ample supply	10		
All parts of home supplied	10		
Good condition plumbing	10		
Soft water provided	10		
3. Foods in My Home			
A well-balanced diet	10		
Right diet for occupation and environment	10		
Foods easily digestible	10		
Foods economical	10		
Foods properly prepared and cooked	10		
4. Care of Foods in My Home			
Clean kitchen and utensils	10		
Good refrigeration	10		
Sterilization and pasteurization	10		
Proper use of preservatives	10		
Protection from insects, etc.	10		
5. Household Pests			
No flies	10		
No mosquitoes	10		
No body pests (fleas, bedbugs, head lice)	10		
No food or cloth pests (roaches, ants, weevils, clothes moths, etc.)	10		
No rats or mice	10		
6. Removal of Wastes			
Exposed plumbing	10		
All porcelain fixtures	10		
Have a working knowledge of system	10		
Sewer connections or septic tank	10		
Garbage pail properly kept	10		
7. Personal Health Habits (See page 173)	100		
Protection against Disease (See page 174)	50		
8. Fuels			
Warmth obtained	10		
Ventilation and protection against loss of heat	10		
Economy of fuel	10		
Economy in time and work in attending to heating plant	10		
Efficiency of cooking stove	10		
9. Clothing, Bathing, and Ventilation			
Proper outer clothing	10		
Proper and clean underclothing	10		
Bathing	10		

HOME SCORE CARD — *Continued*

	Perfect Score	My First (Guess) Score	My Final (Real) Score
9. Clothing, Etc. — *Continued*			
Proper bedroom hygiene	10		
Proper home ventilation	10		
10. Lighting My Home			
Sunlight plentiful	10		
Windows ample, wall papers good reflectors	10		
Artificial lighting economical	10		
Proper lighting for all kinds of work	10		
Good systems of lighting used	10		
11. Proper Care of My Eyes			
See Chapter XVI, Page 266, for items	50		
12. My House			
Detached house	10		
Home owned, not rented	10		
Bedrooms and comfortable living room	10		
Suitable dining room	10		
Convenient kitchen	10		
Bathroom, hot and cold water	10		
Heating plant adequate	10		
Cellar with cold closet	10		
House new	10		
House in good repair	10		
13. The Home Grounds or Parks, Playgrounds, and Library (See pages 295 and 296)	50		
14. My Home Garden			
General appearance	10		
Choice of vegetables	10		
Freedom from pests	10		
Evidence of planning	5		
Care of tools	5		
Value of produce	10		
15. Devices for Convenience and Labor Saving in My Home			
Electric and gas devices	15		
Cleaning helps	10		
Kitchen helps	10		
Other helps: sewing machine, telephone, etc.	10		
Tools and work room	5		
16. My Indoor Recreations			
Score based on points mentioned in Chapter XXIV. See Score Card, page 388	50		
17. My Outdoor Recreations			
Score based on points mentioned in Chapter XXV. See Score Card, page 407	50		
Grand Total	1000		

Why not undertake as a special project the improvement of the series of score cards, with addition to or subtraction from this list.

REFERENCE BOOKS

Allen, *Civics and Health* (Advanced). Ginn and Company.
Conn, *Bacteria, Yeasts, and Molds of the Home.* Ginn and Company.
Davison, *Human Body and Health.* American Book Company.
Hunter, *A Civic Biology,* Chapter II. American Book Company.
Hunter, *Laboratory Problems in Civic Biology,* Chapter II. American Book Company.
Jewett, *Town and City.* Ginn and Company.
Tolman, *Hygiene for the Worker.* American Book Company.
Van Rensselaer — Rose — Canon, *Manual of Home Making* (Teacher's use), Chapters I, II. The Macmillan Company.

CHAPTER III

NATURAL RESOURCES OF HOME ENVIRONMENT

Problems. — 1. *What things about us do we get directly from nature?*

2. *What is air, and how does it satisfy a human need?*
3. *How are we dependent upon the sun?*
4. *Why are water and food of such importance?*

Experiments. — 1. To show the reality of the air.

2. To prepare and observe the properties of the principal gases in the air.

3. To show what part of the air is oxygen.

Project I. — To MAKE A HOME LABORATORY.

1. A suitable space and table.
2. What source of heat?
3. How arrange to collect gases?
4. What equipment needed to start?
5. Cost?

Project II. — To DISCOVER AND REMEDY ANY HARMFUL EFFECTS OF AIR ABOUT THE HOME PREMISES.

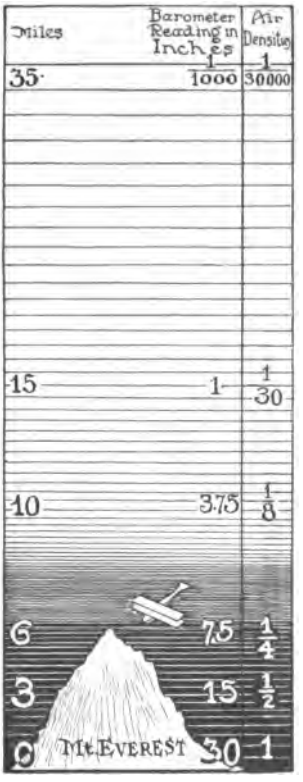
1. Look for:
   a. Decaying timbers, boards, and trees.
   b. Rusting iron, hinges, fences, screens, tools, and stovepipe.
   c. Tarnishing metal as copper and silver.
   d. Any other changes observed due to air.
2. To find out the proper way to prevent and to correct the harm.
3. Apply the remedy.

Suggested Projects.

1. TO PRODUCE AN ARTIFICIAL AIR AND COMPARE ITS PROPERTIES WITH NATURAL AIR.

2. TO MAKE A STILL AND PRODUCE DISTILLED WATER IN MY HOME LABORATORY.

3. TO PRODUCE FIRE BY SOME PRIMITIVE MEANS.



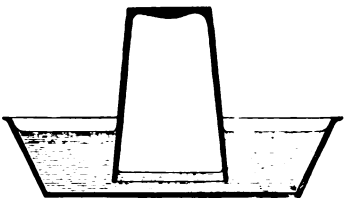
The ocean of air.

What is environment? — Every boy and girl, yes, and every living plant and animal, no matter where they live, come in contact with certain things in their surroundings. Air is everywhere around us. Light is necessary to us, so much so that we use artificial light at night. We live either on soil in the country, or if in the city, we come in contact with the hard and often dirty paving stones and sidewalks. Water and food are both necessary. If the temperature falls below a certain point, we put on heavier clothes. Heat, then, is evidently a necessary factor or part of our surroundings. All these things together, air, water, heat, light, food, soil, and the living things that surround us, make up our *environment.*

Living in an ocean of air. — We are all fully aware every day that air is about us. We live in an ocean of air,

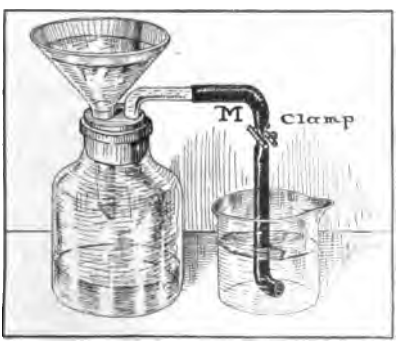
or, in fact, at the bottom of it. We know that it surrounds us, for does not moving air turn our windmills, blow off our hats, blow out lights, uproot trees, and even wreck houses and whole settlements at times?

We know that air occupies space, for if we force an "empty" glass upside down into a pan of water, we find that the water does not enter the "empty" space. We know that air is capable of holding things up. It pushes against our kites. It holds up balloons. It even holds up the moving heavier-than-air machines, or airplanes. The first man who ever flew in an airplane took his simple machine to the crest of a hill, up which a strong wind was blowing. He then launched the glider, for there were no motors used at first in the air, and the force of this air against the flat wings of the machine held him up for a time.



Is the glass really empty?

We may see further evidence that air is a real substance by performing the following experiment.



Experiment. — To show the reality of air.

Materials: Eight-ounce wide-mouth bottle. Two-hole rubber stopper. Funnel. Glass tube. Rubber tube. Clamp. Beaker.

Method: Arrange the apparatus as in diagram.

Observations and Conclusions: When the clamp is closed why does the

water remain in the funnel? If the mouth of the tube *M* is deep in the water when the clamp is opened, and the water runs out of the funnel, what evidence do you see to prove that something is leaving the bottle?

What air really is.—Were any one of us to think over all the possible uses of air, we would probably say its most important use is in the human body, for do we not all use air in breathing? But is breathing anything like burning? Experiments may help us to find this out. If we cover a burning candle with a glass tumbler or cheese dish we notice that the candle goes out in a short time. If we uncover the candle and light it again it will go on burning. If we cover it, it goes out again as before. It is evident that some change takes place in the air during the burning of the candle. Perhaps something in the air is necessary for the burning and it is quickly decreased when we limit the supply of air by inclosing a burning candle in the tumbler.

We are told by men who have analyzed air that about 99 per cent of it is made up of the two gases, oxygen and nitrogen. If we prepare these gases and study their properties, it may help us to explain the part that the air plays in burning matter and in supporting life and also to show us whether it is the oxygen or the nitrogen which is used in these processes.

Experiment.—To prepare and to observe the properties of the principal gases in the air.

1. OXYGEN

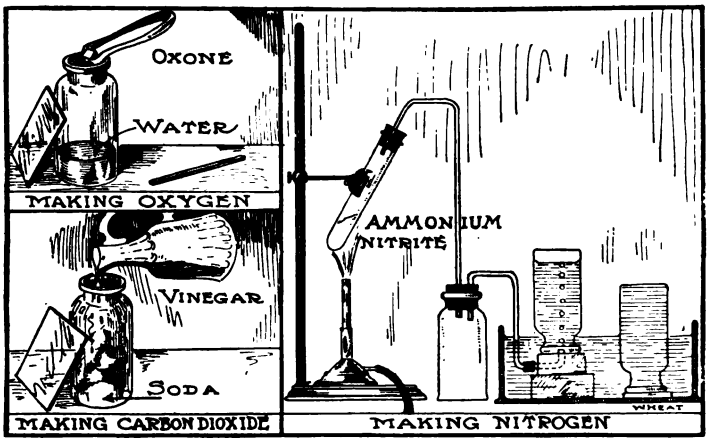
Materials: Small wide-mouth bottle or glass. Glass cover. Wood taper. Oxone. Candle.

Method: Drop a piece of oxone about half an inch square into the glass tumbler containing a small amount of water. Light the wood taper. Blow out the flame, leaving a glowing coal at the end. Thrust this into the glass. Name the characteristic property of oxygen shown. Will the candle burn in oxygen?

2. CARBON DIOXIDE

Materials: Vinegar (or hydrochloric acid). Baking soda (or limestone). A glass or beaker. Glass cover. Wood taper. Lime water. Test tubes.

Method: Pour two tablespoonfuls of vinegar upon a teaspoonful of soda in the glass. Cover immediately. After a minute or two slide the cover to one side and thrust a burning taper into the glass. Produce carbon dioxide in a test tube. Hold the mouth of this tube at an angle over the mouth of a second tube containing some lime water. Carbon dioxide will flow into the lower tube.



After a minute or two, close the lime water tube with the thumb and shake. This is the *lime water test.*

Observation and Conclusion: What characteristic property of carbon dioxide does this show? Result of lime water test?

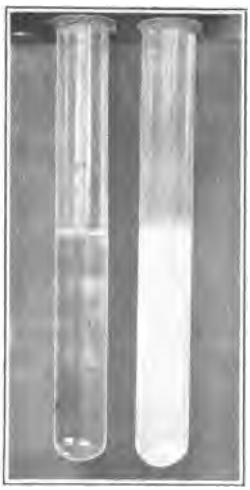
3. NITROGEN

Materials: Bunsen burner. Test tubes. Rubber stopper. Delivery tube. Shallow dish. Small wide-mouth bottle. Wood taper. Ammonium nitrite. Lime water.

Method: Heat ten grams of ammonium nitrite in test tube and collect the gas by displacement of water as shown in the diagram. When the bottle is full, cover and remove from the water. Open and thrust a burning taper into it. Apply the lime water test.

Observation and Conclusion: Does nitrogen resemble oxygen or carbon dioxide in its relation to fire?

What makes the candle burn? — If we were to place a lighted candle in the jar in which the candle went out (page 42), we would find that it does not burn. Evidently some part of the air caused that candle to burn. Let us try to find out whether it is the oxygen. We have seen that wood burns in oxygen and we guess that it is oxygen that makes it possible for the candle or splinter to burn in the air. Suppose we introduce some oxygen into the glass in which the candle will not burn. After mixing we insert a lighted candle and find that it does burn, acting very much as it did in the open air. The mixed gases in the tumbler evidently help the candle to burn. There can now be no doubt that the oxygen of the air is needed to make the candle burn. It is equally essential to us in breathing as we shall learn a little later.



The limewater test for carbon dioxide.

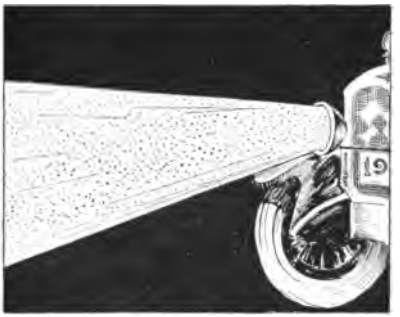
Those of you who have started a home laboratory will be interested to collect oxygen in bottles and to burn other substances in it, as sulphur and iron. For burning iron use picture cord wire. Unravel the end, warm, dip in sulphur, light the sulphur, and thrust into the jar of oxygen.

Still another gas in the air. — If we were to leave a jar containing limewater in the open air overnight, we would find in the morning a whitish film on the surface of the liquid. If we prepare a gas by pouring a little vinegar or hydrochloric acid upon cooking soda and pass it through

limewater, we find that the liquid becomes milky in appearance. If we shake a little limewater in the jar after burning wood or a candle in it, we find that the limewater turns milky. Evidently we might use this test, known as the limewater test, to prove the presence in the air of a gas formed when certain things are burned. Do you see why? The chemist tells us that this gas which is produced by mixing soda and vinegar is carbon dioxide. He uses limewater to test for the presence of carbon dioxide. Carbon dioxide is formed, as we shall find later, by the union of oxygen and a substance called carbon when anything containing carbon is burned. Carbon dioxide is always present in the air, although in very small amounts, about .04 per cent in out-of-door air. It is constantly being given off into the air by decaying vegetable matter, by burning fuels, and by breathing animals.

This shows that water is present in the air.

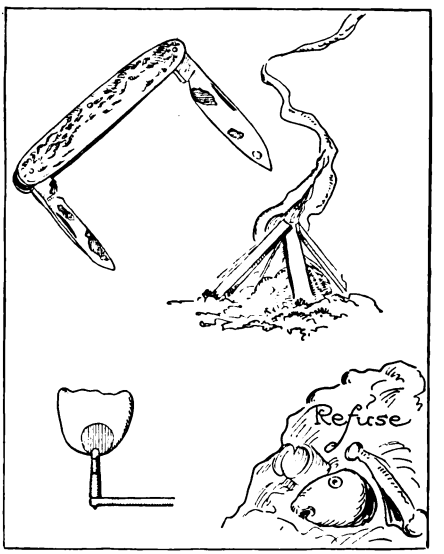
Water in the air. — Air is really a very complex substance, and contains besides the gases mentioned, more or less water. You can easily prove this by mixing a little salt with ice in a test tube, and observing the little drops of moisture which form on the outside of the tube. Where does it come from? In addition to water, several gases, among them argon, are found in small quantities in the air.



There is dust in practically all the air we breathe.

Impurities in the air. If you allow a beam of sunlight to pass through a small crack into a darkened room, you will see thousands of tiny specks floating in the air. These little particles are perhaps soot, dust, or other bodies. In some cities, like Pittsburgh, the smoke is always a constant factor, although it does not seem to harm people very much, but where factories are numerous, we sometimes get poisonous fumes or gases as part of the air we breathe.

Combustion.— We have seen from the experiments we have performed that when the gas oxygen is present, wood or a candle may be burned. Heat and light always accompany this burning. Combustion or burning in pure oxygen is much more intense than it is in air. Iron and other metals can be burned in



What kinds of oxidation are shown here?

pure oxygen, while in ordinary air the nitrogen dilutes the oxygen and thus weakens its action.

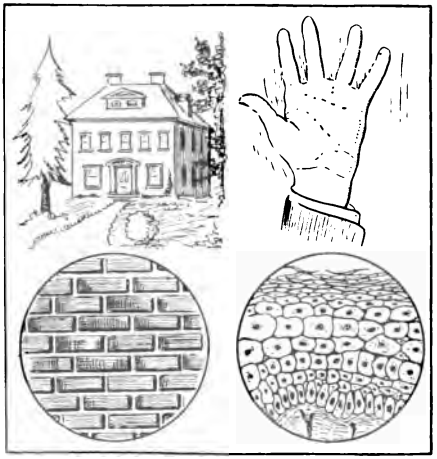
Oxidation. — In the series of experiments we have just performed, burning was simply a union of oxygen with the substances burned, but all around us this union with other substances is taking place without producing any flame. You are all familiar with the fact that iron rusts. This is caused by the union of iron with oxygen. Such oxidation is relatively a slow oxidation. A similar process of oxidation attends the decay of organic matter. In the case of combustion the action is much more rapid, and both heat and light are given off.

Amount of water in the human body.

Water. — Every boy and girl knows that water is necessary for the life of both plants and animals. This can easily be proved by allowing some living plant to wilt, and then adding a moderate amount of water to the pot in which it grows. What causes the leaves to raise themselves? We say that the plant takes up water. This is true, although we cannot at this time explain what happens inside of the plant. Any boy or girl who has had to go without water for several hours knows how necessary it is and how uncomfortable one can be without it. In the World War water played a striking part, especially in General Allenby's campaign against the Turkish army in Palestine. The Turks had a saying that "The Christians will not capture Palestine until the Nile flows into the Jordan." This meant, of course, that they would never capture it, because the Turks believed that such a thing was impossible. But

when General Allenby's army marched across the desert into Palestine, the British engineers built a pipe line which actually did carry water from the Nile under the Suez Canal and supplied the army in the desert with fresh, pure water, so the saying of the Turks was carried out almost as if it had been a prophecy.

No one would think of building a house or locating where there is no supply of water, and modern science has shown that pure water is one of the greatest factors in good health. Besides using water at home for washing, and sprinkling the lawn, we use it in the form of ice and as steam or hot water to heat our houses, to turn motors which generate power and save labor, and in many other ways of which you can think. Why not try to find out how many ways water can be used by man in the home? This would make an excellent home project. But in addition to these uses, the human body needs water, first because a very large percentage of it, about 65 per cent, is made up of water. Furthermore, in order that foods may become part of the body they must first be dissolved in water and soak through the walls of the food tube to become part of the



Cells are the units of building material in the human body as bricks are of the house.

blood and in this form go to the various *cells* or units of building material in the body. In addition to this, water is necessary in order to get rid of the wastes of the body. These wastes must also be dissolved in water and carried off in it, so that water plays an important part in our lives.

What is soil? — To the average boy and girl brought up in a large city, the word *soil* does not mean much. Sometimes they may play on vacant lots or go to the parks where they see dirt or soil, but they come in contact with it less frequently than the country boy to whom soil means hard work. Gardens depend on soil. They must be weeded and attended to. Crops grow in soil. They must be cultivated. Fruit trees grow in soil. They require much care. To understand what soil really is and how it came to be, we must look back a great many million years. Long ago, we are told, the earth was a great white-hot mass of rapidly revolving material. As this mass cooled the greater part of it became rock. Later the rock, alternately expanding with heat and contracting with cold, began to crack and crumble so that little fragments were formed. These pieces were ground up by the action of ice and running water, and the atmosphere caused them to decay. Gradually this covering of tiny pieces of rock became soil. Examination of beach

Formation of inorganic soil. (After Blackwelder and Barrows.)

sand or river gravel will show you how small particles of soil might thus be formed.

After plants and animals began to live on the earth, their dead bodies, upon decaying, became a part of the soil. Any boy who has been in a forest knows that the soil is covered with dead leaves, decaying wood, and the like. He also knows that if he digs down through the tangled

Formation of organic soil or humus. (U. S. Forest Service.)

mass of roots and other materials forming black rich soil, he may at last come to sand or to crumbling rock.

Soil and the home. — Soils play a very important part in the health of our home. If the soil is of sand and not clay, water will drain readily, and we shall not be troubled with standing bodies of water after rains. Our garden will grow better and conditions of drainage will be good. We shall later see that the fertility of the garden depends largely upon the kind and composition of soil, and this means that the home grounds may or may not be attrac-

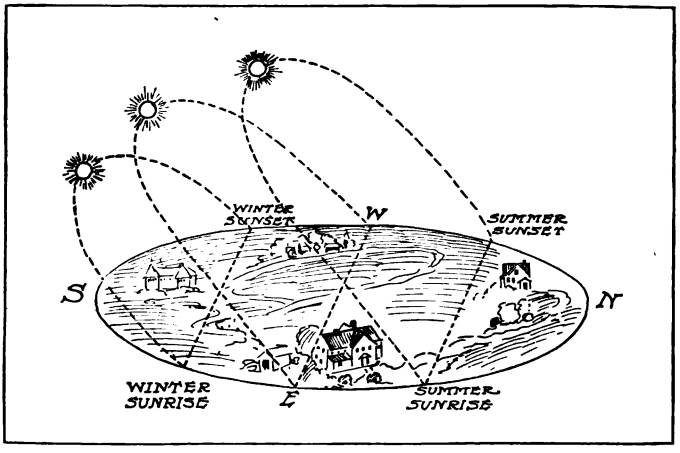
tive, depending on the kind of soil. We shall find later that the soil of the garden or lawn, instead of being dead as we thought, is really a battlefield in which millions of little germs are engaged, some in causing decay of materials there, others in making the decaying material available or valuable for plants in the form of nitrogen compounds, while still others break down these nitrogen compounds and allow some of the nitrogen to pass off into the air.

The effect of light upon a growing plant.

Light and heat. — What would you do without light? We must all realize the importance of light when we remember how much artificial light means to us in our homes. All green plants need light. Notice the geranium or oxalis growing in your window garden. The stems turn to the light, and expose as much leaf surface as possible to the sun's rays. Without light no green plant can exist, and without green plants no animals can exist. Think this over and see if it is not true. Your beefsteak came from a cow which lived upon grass which grew as a result of having, among other things, sunlight. You know, too, there can be no life without heat.

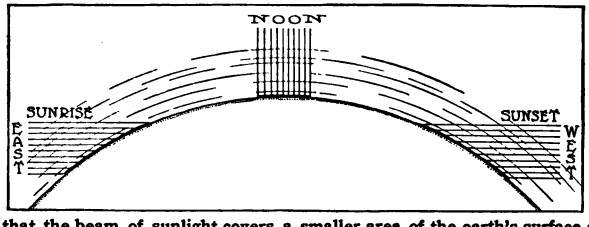
The sun and rays of heat. — Have you ever stopped to think why it is warmer in summer than in winter? A glance at the diagram on page 52 will show you. The sun's rays come more directly upon us in summer, and give us more heat. If you do not believe the sun gives off heat,

use a burning glass on your fingers instead of on a piece of paper. This heat or energy is more useful than we at first are aware. *Energy is the power to do work.* The sun



How the sun's position varies throughout the year. Does it help explain our cold winters and warm summers? (After Todd.)

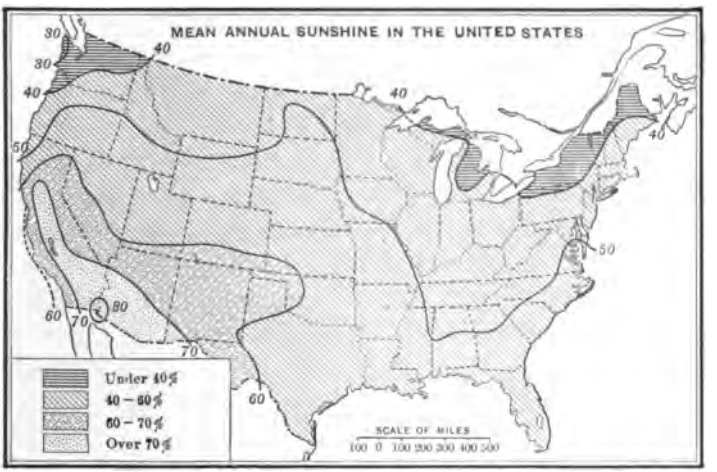
works for us in many ways, and the most wonderful of all is the making of food by green plants. The length of time that the sun works for us depends upon the section of



Notice that the beam of sunlight covers a smaller area of the earth's surface at noon than at any other time.

the country in which we live. Study the sunshine chart to see how much sunshine you have in your own locality.

Foods. — Another resource of our environment is food. We know that when we are hungry we eat, but we cannot tell why, nor can we tell what the foods do for us. This will be the subject of a later lesson. All we need to know now is that these foods which are taken into our bodies may be used for two purposes, to build more body material, and to release energy or work power in the body. We grow



up to about the age of twenty, and may increase in weight after that, but it is not easy for us to realize that the food we take into our bodies must actually be oxidized or burned in order to release energy or work. But if we think back to one of our former experiments, this is not so difficult to understand. You remember that when limewater turned milky, it was a test that carbon dioxide had been released, or that something containing the element carbon had been oxidized. If we expel air from our lungs into a jar of limewater we notice that in a very short time the

limewater becomes milky in color. From former experiments, it is evident that oxidation must be taking place in our bodies. It would not require much of a stretch of one's imagination to think out this whole process, and in this way compare our own bodily machine to that of an engine. Coal may be the source of power to drive the engine. In the case of our bodily machine, what is it that corresponds to the coal of the mechanical machine?

Scoring my environment. — The following score card is a tentative project. We shall find much in the future chapters of this book and its companion book on Civic Science in the Community that may cause us later to wish to change our score. You may think of other items to score that seem more important to you. If so, make a score card of your own. Modify any of the conditions here that you think ought to be changed and bring your suggestions into class as a problem for discussion. Get help at home where you need it on this card and above all, try to be honest in your estimates. Remember you do not cheat anybody but yourself in a score which *you know* is incorrect.

REFERENCE BOOKS

Barber, *First Course in General Science*, Chapter II. Henry Holt and Company.

Blackwelder and Barrows, *Elements of Geology*. American Book Company.

Caldwell and Eikenberry, *General Science*, Chapters II, VI, VIII. Ginn and Company.

Clark, *Introduction to Science*, Chapter IV. American Book Company.

Dorrance, *The Story of the Forest*. American Book Company.

Hunter, *Laboratory Problems in Civic Biology*, Chapter II. American Book Company.

Smith and Jewett, *Introduction to the Study of Science*, Chapter II. The Macmillan Company.

Trafton, *Science of the Home and Community*. The Macmillan Company.

Van Buskirk and Smith, *The Science of Everyday Life*, Projects II, III, IV. Houghton Mifflin Company.

Weed, *Chemistry in the Home*, Chapters II, VII, IX. American Book Company.

SCORE CARD. THE NATURAL RESOURCES OF MY ENVIRONMENT

	Excellent	Fair	Very Poor	My Score	
					Total
AIR	Air pure No dust (2) No smoke (2) No bacteria (2) No odors (2) Much vegetation in vicinity (2)	Air contains dust at times (1) Some smoke (1) Some bacteria (1) Some odor or dangerous fumes (1) Parks (1) Public playgrounds (1)	Air has much dust (0) Smoke at all times (0) Many bacteria in air (0) Much odor or poisonous fumes (0) No parks or playgrounds (0)	....	....
WATER (City boy and girl score 10 if in a city with good protected water supply)	Spring or well tested by bacterial expert; driven or artesian well; all protected at surface (8) Rain water provided in cement cistern; no vegetable matter in supply (2)	Spring or well not recently tested. Protected by cement curbing. No privy or cesspool within 100 ft. (4) Rain water in tank or barrel; no cement (1)	Spring or well not properly protected. Cesspool or privy within 100 ft. (0) No rain water, or barrel open with wigglers in it (0)	....	....
SOIL (City girl and boy score 10 if living in apartment)	Soil; sandy loam (3) House high, drainage from house (3) No pools or standing water (2) Cellar always dry (2)	Soil; sandy and dry or part clay (2) House level with street, drainage fair (2) Pools of water sometimes after rain (1) Cellar sometimes damp (1)	Soil; clay (0) Drainage poor, house below street level (0) Standing water after rain (0) Cellar always wet (0)	....	....
WEATHER	Sunlight 50% of the time (4) Temperature rarely over 95° or under −20° F. (3) No damaging floods or severe drouth (3)	Sunlight 40% of the time (2) Temperature rarely above 100° or below −30° F. (2) Occasional damage by floods or severe drouths (1)	Sunlight under 40% of the time (0) Temperature rarely more than 105° or below −40° F. (0) Frequent damage from floods or drouths (0)	....	....
FOODS	Home supply of fruits, vegetables, eggs, and poultry (5) Food purchased reaches home in sanitary condition and fresh (3) Foods relatively cheap (2)	Home supply of either fruits and vegetables or eggs and poultry (3) Food purchased reaches home in fair condition, not always fresh (1) Foods moderate in cost (1)	No home supply of foods; no garden, or chickens kept (0) Foods neither sanitary nor fresh (0) Foods expensive (0)	....	....
GRAND TOTAL					

NOTE: You are expected to pick out the items that you think cover your conditions and score under proper column. For example, if food supply was all purchased but was sanitary, fresh, and cheap, you would score (0), (3), and (2) respectively. Do not fill in the above blank, but make a similar score card in your notebook.

PART II. GOOD HEALTH IN THE HOME

CHAPTER IV

PURE AIR

Problems. — 1. *To understand how and why we breathe air.*

2. *To understand the need of ventilation and how to ventilate our rooms.*

Experiments. — 1. Does air have weight?
2. To illustrate the process of breathing.
3. To determine some products of respiration.
4. To demonstrate the principles involved in ventilation.

Project I. — CAN I INCREASE MY LUNG CAPACITY WITHIN TEN WEEKS?

1. What is my chest expansion at the present time?
   Take measure under the arms, clothing removed.
   (1) After taking a good normal breath.
   (2) After exhaling a normal breath.
   (3) After filling the lungs as full as possible.
   (4) After forcing all the air possible from the lungs.
   The difference between (3) and (4) is the chest expansion.
2. Make a tabular form for recording these four measurements and the chest expansion. Take weekly measurements for ten weeks.
3. Find out what exercise is good to develop the lungs and practice it faithfully each day.

4. From the weekly reports kept make a graph to show the changes in your chest expansion during the ten-week period.

Make a report explaining what exercises you have used, and include tables and graph.

Have you experienced any ill effects or any beneficial effects from this work?

Note: If desired, actual lung capacity may be tested with a spirometer, though the measurements suggested give satisfactory results.

Project II. — How to secure pure air in my bedroom.

1. What methods are used in ventilating?
   How do my friends ventilate their rooms, — windows open at top, at bottom, at both top and bottom; two windows open? Open doors to help air circulation. Dust annoyance. Advantage and disadvantage of thin muslin or cheesecloth windows. Deflecting devices. Screens in room to deflect drafts.
2. Need of fly and mosquito screening the entire length of window.
3. Plan of room showing arrangement of essentials.
   Indicate with arrows probable movement of air.
   Effect of winds; direction of wind; no winds.
4. Make a complete report of your investigation, illustrating with diagrams, clippings, and pictures from papers and magazines.
   Give specifically best plan for ventilating your own bedroom.

Project III. — To prepare for life saving where artificial respiration must be used.

1. You must qualify as a *good* swimmer.
2. You must understand dangers from "live" electric wires, and how to remove the shocked person from such wires.
3. You must know how to rescue a person in water.
4. You must be able to use the Shaefer method of artificial respiration.

Reference: *American Red Cross Abridged Textbook on First Aid*, Blakiston, or *Boy Scout Manual.*

When you feel qualified for this work, write a report on what you can do, and how you would act in case of accident requiring artificial respiration.

Suggested Project.

1. TO MAKE A SUBSTITUTE FOR THE SPIROMETER WHICH YOU CAN USE IN TESTING YOUR LUNG CAPACITY.

Thought Questions.

1. Do you breathe normally immediately after holding the breath as long as possible?

2. Can you "hold your breath" longer with lungs inflated or deflated? Why?

Why is pure air necessary? — This is an age when people seem to recognize the necessity of pure air for healthy living. People build houses with sun parlors open to the air, and with sleeping porches where the entire family may sleep winter and summer. New laws require city houses and tenements to be built with an adequate air space so that sleeping rooms may have a proper amount of air going in through the windows at night. We have outdoor schoolrooms and both teachers and doctors preach the need of proper ventilation.

An out-of-door sleeping porch.

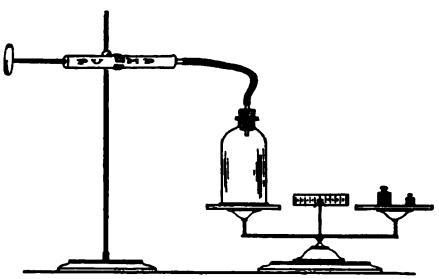
It seems almost incredible that over sixty barrels of air pass in and out of your lungs every day of your life. If you will count the number of breaths you take in a minute while you sit quietly in the schoolroom (number of times your chest rises and falls), and then if you will exercise vigorously for two minutes (a stationary run with hands raised above the head will be a good exercise) and again

count the number of times you breathe in one minute, you will notice a distinct increase. Compare this with the forced draft in the engine. Evidently the body needs more air when we exercise than when we sit quietly, and this wonderful human machine responds automatically to its demands.

Air pressure and what it is. — We are told that air presses down on us with a force of fifteen pounds to the square inch. It is easy to understand that water exerts pressure on a vessel which contains it, but it is more difficult to think of air as having weight and so exerting pressure. We may actually see in an experiment whether or not air has weight by weighing a bottle before and after pumping air out of it.

Experiment. — Does air have weight?

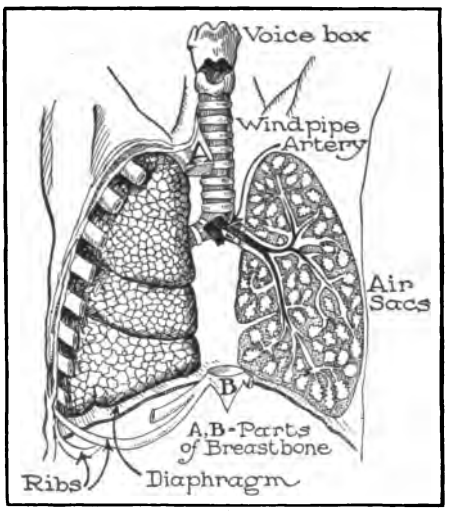
Materials: A two-liter bottle with one-hole rubber stopper. Glass and rubber tubing. Burette clamp. Mohr clamp. Platform scales. Sand or weights. Air pump for suction or compression. Vaseline.



Method and Observations: Pass the glass tube through the rubber stopper and attach a rubber tube to it. Place the Mohr clamp on the rubber tube. Set the bottle on one arm of the platform scales and fasten the rubber tubing to a clamp on a ring stand leaving the tubing loose enough to move freely up and down with the movement of the balance. Make the stopper tight with vaseline and tie it in if air is to be forced into the bottle. Exactly balance the bottle by pouring sand into a jar or using weights on the other balance arm.

By means of a force pump attached to the end of the rubber tube force air into the bottle. What is the evidence to show if air has weight? Disconnect the pump to open the tube to the air. Result?

How we breathe. — We all know that somewhere inside of our bodies there are spongy structures we call lungs. The diagrams (page 70 and below) show us that from the mouth cavity down the front of the neck leads a tube known as the air tube, or *windpipe*, and that this tube branches into two pipes, or *bronchial tubes*, which in turn branch again and again and end in tiny grapelike clusters of little *air sacs*, which are too small to be seen with the naked eye. In these air sacs, which have extremely thin walls, the oxygen of the air comes in contact with the blood, the blood taking some oxygen and giving up in return some carbon dioxide, which has been brought there from the various parts of the body where work is being done. Around these delicate lungs are placed the *ribs*, so that as the diagram shows, the two lungs are held within a sort of bag or cavity. This chest cavity is bounded at the bottom by a muscular wall, the *diaphragm*, which extends across from the front to the back of the body, and makes an air-tight surface surrounding the lungs. If we now study a simple piece of apparatus shown in the picture on the next page, we shall be able to understand how we breathe.



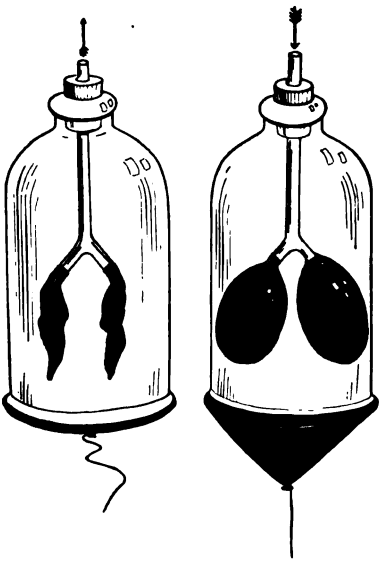
The human breathing organs. Notice one lung is cut open to show the air sacs.

Experiment. — To illustrate the process of breathing.

Materials: A bell jar fitted with a rubber cork, and wide glass tubing from the ends of which are tied two rubber balloons. Over the lower end of the bell jar is tied a piece of sheet rubber such as dentists use, with a piece of string attached at the middle outside the jar.

Method: Pull on the string so that the cavity inside the jar is increased in size. What effect does this have on the rubber balloons? Allow the rubber diaphragm to go back to its former position by releasing the tension of the string. What happens to the balloons? Why?

Conclusion: Explain the different actions you have seen and apply them to the action of breathing. If your finger were placed on the tube leading into the balloons and then the rubber diaphragm were pulled, do you think the action would be the same? Try it.

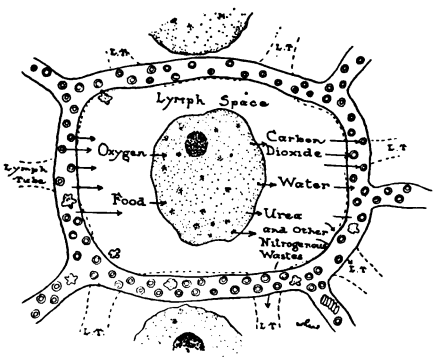


Apparatus to show the mechanics of breathing.

It is very evident from this experiment that the air pressing in on the balloons through the tube causes them to expand. If we now compare this apparatus in its working with our own lungs, ribs, and diaphragm, we are able to understand how we breathe. If you will stand upright and take a full deep breath, you will readily notice that as your chest expands the ribs rise. This makes the chest cavity somewhat larger. As the ribs rise the muscular diaphragm assumes a straighter line. The lungs lying in this cavity are now filled by the air which rushes into the larger space thus made. This enlargement of the chest cavity

and the consequent filling of the lungs with air is known as an *inspiration*. After we have raised the ribs, we allow the muscles which pull them up to relax; as the ribs sink back and the diaphragm expands curving up into the chest cavity, the chest cavity becomes smaller and pushes the air from the lungs. This is an *expiration*.

Distinction between breathing and cell respiration. — Most boys and girls think that breathing takes place in the lungs. This is true, but we would soon die if the oxygen stopped there. As a matter of fact the lungs are simply organs which serve to pass oxygen over to the blood and to take carbon dioxide and waste matter from it. The real respiration takes place in the cells of the body which do work for us. If we work the muscle of the arm, then that muscle in order to do its work must oxidize some fuel or food material which has been carried to it by the blood. If we work with the brain, then food must be oxidized in the brain cells in order that energy may be released there. The blood, like a railroad train, carries the oxygen from the lungs to all places in the body where oxygen is needed. In the blood are little cells known as red corpuscles. These cells have the peculiar ability to carry oxygen. They are also able to give up this oxygen where it is needed in the body. Thus the blood becomes a medium of exchange



The respiration of cells.

between the cells which need oxygen and the air which is taken into the lungs. The products formed when oxygen is used in the body are exhaled in the breath and may be detected by simple tests.

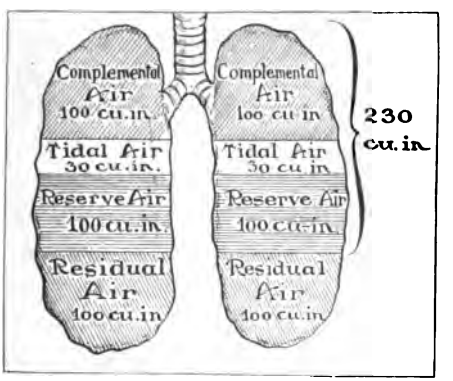
Experiment. — To determine some products of respiration.

Materials: Glass tubing. Limewater. Test tube.

Method and Observations: Blow the breath through a large, dry glass tube until there is evidence of material deposited. From its appearance what do you judge this to be? Blow the breath through limewater in a test tube for a short time. What change occurs? Recall the meaning of this test, which was previously shown in Chapter III.

Conclusion: What are two substances produced in our bodies which escape in our breath?

The necessity for deep breathing. — The blood, too, carries back to the lungs carbon dioxide which has been formed in the cells as a result of the work done there, and this carbon dioxide, as we have seen by our limewater test, is expelled from the lungs during respiration. The lungs during ordinary breathing do not expel more than one seventh of their total load of air. More of the air in the lungs can be expelled when we take a deep breath, but there is always some air left in the lung sacs known as residual air. This air must be very impure, as it lacks



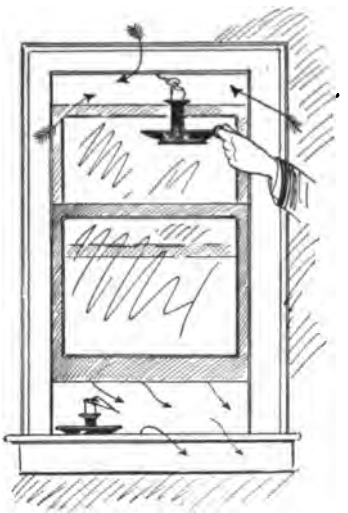
Tidal air **is that air taken in and expelled during ordinary breathing.** ***Complemental air*** **is what we can take in, in addition to tidal air in a full deep breath.** ***Reserve air*** **is what we can force out in addition to tidal air by forced expiration.** ***Residual air*** **is that which always remains in the lungs.**

oxygen and has much carbon dioxide and other waste products as well. It is therefore highly important that we force out as much of this air as possible rather frequently, and we can do this only by deep breathing. One of the best deep-breathing exercises, which should be practiced several times daily out of doors, is to raise the arms well from the sides and breathe deeply while we do this, hold the breath for three seconds, exhale, and repeat fifteen times.

Water, carbon dioxide, and other wastes given off through the lungs. — A study of chemistry shows that as wood, which contains carbon and hydrogen, combines with oxygen it produces two substances, carbon dioxide and water. A chemist writes these two substances as CO_2 (carbon dioxide) and H_2O (water). Chemical elements are very simple substances of which oxygen, hydrogen, and carbon are examples. They always unite in definite proportions. For example, water is always composed of $\frac{2}{3}$ hydrogen and $\frac{1}{3}$ oxygen by volume, no matter how much of it there may be. Foods contain carbon, hydrogen, and oxygen, and when they are oxidized in the body, produce other substances; among these are carbon dioxide and water. You are, perhaps, familiar with the odor that is noticed when one passes from out of doors into a closed room where several people have been for some time. The "stuffy" odor is caused, in part at least, by certain waste materials which have been passed off through the lungs and skin into the air.

Need of ventilation. — It therefore becomes necessary in rooms where people are gathered, such as schoolrooms, churches, "movie" theaters, and the rooms of our own homes, to have the air constantly changed in order to get rid of the odor, moisture and carbon dioxide, and

to supply fresh air with its greater load of oxygen in their place. We must not think that in breathing we use all of the oxygen from the room. This would be impossible. Neither does the carbon dioxide given out from the lungs make the air unfit to breathe. Recent experiments have shown that man can live in an atmosphere containing only ten per cent oxygen, an amount so small that a match could not burn in it. But you are all familiar with the great feeling of discomfort one has in a closed and "stuffy" room. This discomfort is due principally to the increase in humidity, or water content of the atmosphere, in the room. Circulation of the air will to a certain extent prevent this discomfort. This circulation may be brought about by electric fans, blowers, etc., in large rooms, or by proper ventilation by means of windows in smaller rooms. On the other hand, water in the atmosphere is absolutely necessary for health. In most artificially heated rooms the air is far too dry for health, as people who live in such rooms take cold more easily when they go out of doors. Air may be kept moist by keeping pans of water on the radiators and registers. There is a certain amount of natural circulation due to the difference in weight of hot and cold air.

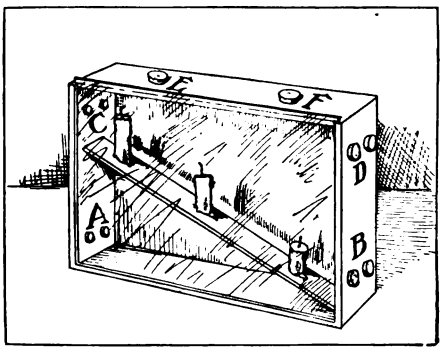


This shows the direction of air currents when it is warmer indoors than out. Can you account for this?

Let us now try an experiment to show how to ventilate properly as a basis for home study.

Experiment. — To demonstrate the principles involved in ventilation.

Materials: A ventilation box. This is to be about 20 inches tall, 2 feet long, and 4 inches thick, having one of its large surfaces of glass. Either the front or back should be grooved to facilitate opening. A slanting shelf one inch wide runs from one lower corner nearly to the opposite upper corner. One-inch holes are bored in the sides and top as suggested by the letters *A* to *F* in the diagram. Corks are used to close these holes. Three small candles are placed on the diagonal shelf equally spaced so that they are at different levels.



A ventilation box.

Method and Results: (1) Light the three candles. Close all the openings. Which candle goes out first? Explain why. (2) Light the candles. Open holes *B* and *C*. Test currents of air by holding smoking joss stick or rolled paper at the openings. Result? (3) Repeat (2), using holes *A* and *D* open. (4) Repeat, using *D* and *C* open. (5) Repeat, using *A* and *B* open. (6) Repeat, using *E* and *F* open.

Conclusions: What facts about circulation of air are shown by the experiments? What facts about changes in air due to burning substances? What facts are indicated which will be helpful in planning circulation of air in our homes? What conditions found in the experiment are not duplicated in a room where we wish to apply the principles of ventilation? In what particulars can we apply the results found here to ventilation of rooms where people are congregated? Is ventilation needed for any other reason than the fact that a part of the oxygen of the air has been consumed?

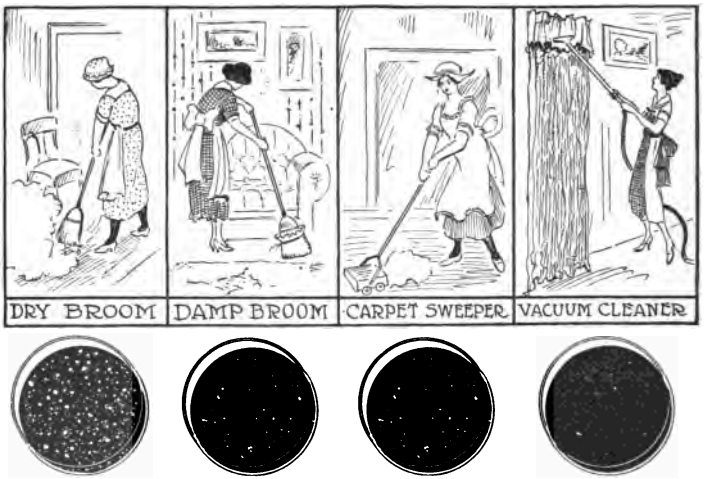
Dust and its dangers. — Not very many years ago an eminent New York physician wrote a book entitled "Dust

and its Dangers." The dangers, as he pointed out, are not in the dust itself, but in the possible presence in the dust of many tiny living organisms known as bacteria, yeasts, or molds. It is very easy to prove the presence of these living plants, for such they are, in the air of the schoolroom. Let us obtain some previously prepared material known as culture medium.[1] This has been placed in a Petri dish, a small glass dish with a loosely fitting glass cover. The dish and contents have been thoroughly sterilized, or rendered free from all living matter by means of heating. Thus we know that the culture medium and everything inside of the dish is dead. If this dish is now opened for five minutes, exposing the surface of the culture medium to the air of the room, then closed and put away in a warm dark place for two or three days, a number of little dots of different sizes and colors will be found growing on the surface of the culture medium (see

Plate culture exposed for five minutes in a school hall where pupils were passing to recitations. Each spot is a colony of bacteria or mold.

[1] This culture medium may be bought already prepared. It is a gelatine or agar-agar preparation upon which germs grow readily. It has been previously rendered free from all living things by sterilization.

illustration). These little masses of material have not grown from nothing. They increase in size day by day. They must be alive. Since everything in the dish was dead, we have to conclude that they came from the air. If we were to examine the material under a very high-power microscope, we would find it composed of millions upon millions of tiny plant forms known as bacteria or molds. These tiny plants



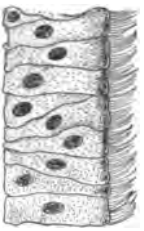
Which of the above methods is the best? What evidence is shown?

grow and thrive in our homes under conditions which we shall investigate more thoroughly later.

Proper methods of sweeping and dusting. — If these germs are present in dust, then it is important for us to have methods of sweeping and dusting which will not raise dust. A good home project for girls and boys would be the working out of the best methods for cleaning their own homes. If we are fortunate enough to have electricity, then an electric vacuum cleaner which sucks up the dust

and dirt without charging the air with it is the best method. Floors should be wiped with a damp or oily cloth rather than swept. Why? An interesting problem would be this: To determine which method of cleaning in the home is the most hygienic. Suggest four methods of cleaning and consequently four different conditions under which you could expose prepared Petri dishes in your own home.

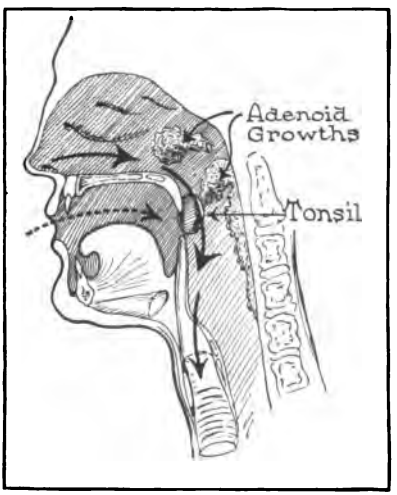
How the organs of respiration are protected from dust. — The nose, the organ of smell, performs several other very important offices. Just near its entrance are many hairs which the air must pass. Down below, in the throat itself, is a soft lining of cells which are provided with tiny whip-like structures made of living matter. These structures, called *cilia*, are constantly in motion, and always whip upwards so as to expel all foreign material from the lungs. The ciliated cells, together with the hair in the nose, prevent most foreign matter, such as dust and dirt with their load of germs, from going down into the lungs. The lining of the nose also moistens and warms the air before it passes to the lungs.



The tubes leading into the lungs are protected from dust by means of ciliated cells.

Hay fever. — Dust, however, often causes us trouble. The disease known as hay fever seems to be caused by dust made up of pollen from different kinds of flowers. This pollen is a violent poison to some people, and causes sneezing, itching eyes and nose, and a feeling of discomfort. Sometimes relief is obtained by means of spraying the air passages, or plugging the holes in the nose with medicated absorbent cotton, but so far no real *cure* has been found except by inoculation with various vaccines made from the agents which cause the trouble.

Diseases of the air passages. — We are probably more aware of diseases of the air passages than almost any other part of the body. Nearly everybody has a cold at one time or another, and we have all heard of and perhaps suffered from ravages of influenza and pneumonia. Other diseases which unfortunately attack the air passages are diphtheria, tonsillitis, laryngitis, pharyngitis, bronchitis, catarrh, croup, and whooping cough.



Section of head and neck showing position of adenoids and tonsils.

Adenoids and tonsils. Tonsils often make much trouble for us. Germs lodge and grow in them and cause many diseases. Infected tonsils should be removed. Polyps are soft jellylike growths in the nose which cause stuffiness, difficulty in breathing, and thickness of voice in children. If present, they should be removed by a physician, as the loss of the sense of smell, as well as much discomfort, may follow. Adenoids are almost always accompanied by breathing through the mouth, snoring at night, and general listlessness and indifference to work and play. Adenoids grow in the back part of the nose, and shut off the air supply through this organ. They should be treated, or removed if very large.

Artificial respiration. — Accidents which shut off the supply of oxygen, are drowning, suffocation from gas,

stoppage of the nose or throat, and electric shock. In case of any accident in which breathing stops, it is necessary to work quickly. Send for a doctor at once. The person should be taken into the open air if possible, the clothes loosened, and artificial respiration started as soon as possible. In the case of drowning, the first thing to do is to get the water out of the lungs and air passages. To do this we must raise the lower part of the body of the patient from the ground so that the water may run out. Lift the patient up quickly two or three times with a jerk, with the arms underneath the abdomen. Do not take more than half a minute to do this. Water from the lungs will thus be forced out. Then at once place the patient on the ground face down, arms outstretched, and with head on one side so that air can get in through the nose and mouth. Place yourself astride of the patient, but without resting any weight on him. Place the palms of your hands across the small of his back, thumbs touching. Then allow your weight to fall on your wrists by bending your body forward. This decreases the size of the patient's chest cavity and forces air out of his lungs. Now release the pressure

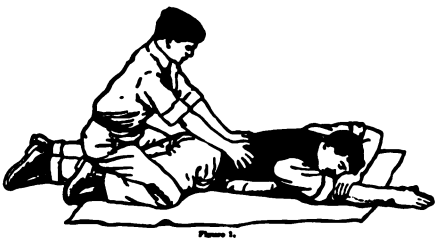


Figure 1.

Figure 2.

Shaefer method of artificial respiration.

by swinging backward quickly. The elastic chest of the patient will go back to its original position, thus drawing air into the lungs. Perform these motions about fourteen or fifteen times a minute, and keep it up for several hours, if necessary, for victims of drowning accidents have been brought back to life after hours of patient work. If there are others to help have them rub the arms and legs toward the body, as this helps the circulation, and as soon as possible cover with warm blankets. As the patient gets better, give him warm drinks and place hot water bags at the hands and feet. Keep a crowd away from the patient, as he needs all the air he can get.

In case of suffocation, where the patient has lost consciousness, start artificial respiration as directed above, and send at once for a doctor. In case of electric shock the patient must first be rescued. Remember that live wires transfer their electricity through the body of the victim. It is necessary to stand on dry wood, cloth, or rubber, and then you should not touch the person you are rescuing with your hands. You may be able to remove the wire with a dry piece of wood, or cut it with an ax having a dry wooden handle. If the victim lies on the wire, place coats under his head and feet and lift him off. As soon as you have rescued the victim start artificial respiration at once, for time is a very important factor here, especially if he has become unconscious. Treatment for lightning shock is the same as for electric shock.

Fainting. — A fainting attack is brought on by a decrease in the amount of blood in the brain. A person feeling dizzy should lie down with the head lower than the body. This will usually prevent fainting and will hasten the return to consciousness of one who has

fainted. Abundant fresh air and loose clothing are helps. Enforced respiration often shortens an attack. Respiration may be stimulated by throwing cold water upon the face and chest. Ammonia may also be inhaled, but avoid letting any drop into the eye or irritating the air passages unduly by holding it too near the mouth or nose.

Why is the head lower than the rest of the body? (After Tolman.)

REFERENCE BOOKS

Allen, *Civics and Health*, Chapters V, VI (For teacher). Ginn and Company.

—— *American Red Cross Textbook on First Aid.* Blakiston's Son and Company.

Broadhurst, *Home and Community Hygiene*, Chapters IX, XI (Teacher's use). J. B. Lippincott Company.

Chapin, *Sources and Modes of Infection* (Teacher's use). J. B. Lippincott Company.

Fisher and Fisk, *How to Live*, Chapter I (Advanced readers). Funk and Wagnalls Company

Hill, *The New Public Health*, Chapters III, IX, XV (Teacher's use). The Macmillan Company.

Hough and Sedgwick, *The Human Mechanism.* Ginn and Company.

Hunter, *A Civic Biology*, Chapters XXI, XXII. American Book Company.

Hunter, *Laboratory Problems in Civic Biology.* American Book Company.

Lee, *Health and Disease*, Chapters VIII, XII (Teacher's use). Little, Brown, and Company.

—— *New York State Ventilation Commission Reports* (Advanced readers).

Prudden, *Dust and Its Dangers.* G. P. Putnam's Sons.

Ritchie, *Primer of Sanitation*, Chapters XX, XXI. World Book Company.

Woods Hutchinson, *Preventable Diseases.* Houghton Mifflin Company.

CHAPTER V

WATER IN THE HOME

Problems. — 1. *To understand the cycle of water in nature.*

2. *What are the available sources of a home water supply?*
3. *How can you tell safe from unsafe water?*
4. *How can water be brought into the home?*
5. *What is a "solution"?*

Experiments. — 1. To find a method of purifying water (distillation).
2. To determine how air pressure can lift water.

Project I. — To make a lift pump.

Plan how you can make a working model of a lift pump or a force pump.

Suggestions. — Large glass tubing and cylindrical lamp or gas chimneys make good pump barrels. Valves are easily made by using sheet rubber with a long tack or pin passing through it.

Your report should contain at least two good diagrams showing your pump model in action.

Project II. — How much water is wasted by dripping faucets?

Devise a method to find out how much water is lost from a leaky faucet. How much could be lost in a year?

If the water is metered, what is its cost?

What would be the difference in gallons lost or in money value per year in the following instances?

1. When the leak is drop by drop.
2. When the smallest possible stream is running.

Let your report include all details of your processes, and also a report on the results of any attempts to stop the loss.

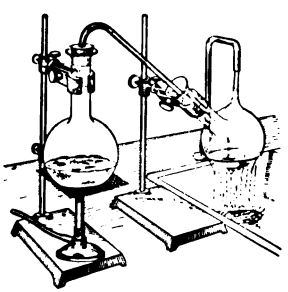
What if similar leaks occurred in half the faucets in town?

Pure water. — What is pure water? We have already seen water condensed as a product of a burning candle, and in a future chapter we shall see that it is the product of burning hydrogen in oxygen. It is, then, a compound produced by the combination of the chemical elements, oxygen and hydrogen. All pure water contains hydrogen and oxygen and nothing else. When other substances are mixed with water there are certain methods by which pure water may be separated from some or all of the impurities. One purifying process is distillation. Let us see if this gives us pure water from impure water.

Experiment. — To find a method of purifying water.

Materials: Two 500 cc. flasks. A one-hole rubber stopper. Glass tube. Ring stand.

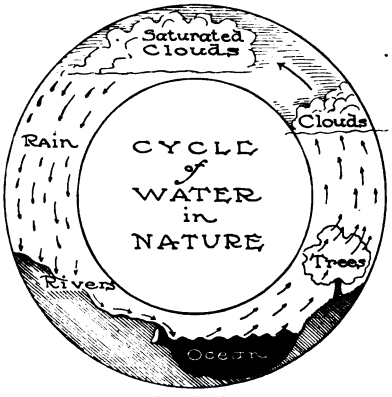
Method: Prepare a sample of impure water by adding a teaspoonful of salt and an equal amount of clay or fine sand, and a few crystals of potassium permanganate to a half pint of water. Fill one flask about half full of the prepared water and place on ring stand. Arrange to carry the steam through a bent glass tube into the other flask which stands under a stream of cold water. Heat the flask which is supported on a ring stand. When an inch depth of distilled water has been prepared remove the heat.



Distillation apparatus.

Results and Conclusion: How does the distilled water compare with the original in appearance? In taste? What can you say regarding distillation as a method for purifying water? Are any of the impurities left in it? Explain fully the process of distillation.

Rain water. — When we think it out rain water must also be very pure, for is it not condensed in somewhat the same way as the drops of water we collected in the last experiment? Breathe on a cool glass. What happens? The little drops of moisture have been condensed because warm, moist air was suddenly cooled. Moisture in the air comes from evaporation from water surfaces and from all moist surfaces. Leaves give off moisture in the form of water vapor. An acre of clover may give off from 500 to 750 tons of water during a single season. The production of one pound of some plant foods requires that two to five tons of water be taken from the soil and most of this is evaporated into the air from the leaves. An acre of Indian corn gives off nearly a thousand tons of water in a season. When this moisture in the air condenses clouds form. From clouds water falls in the form of rain.



Explain this diagram.

How we get rain water. — In many parts of the world people drink rain water. On the islands of Bermuda, for example, great cisterns are cut in solid rock to hold the water, and the people of the islands depend entirely upon this supply. If rain water is collected in clean cisterns or barrels it is perfectly pure. But unfortunately the cisterns and rain barrels are sometimes not clean. Roof drains and gutters are allowed to become clogged with decaying vege-

table matter or sometimes a poor quality of paint used on the roofs will come off in the water. All of these things

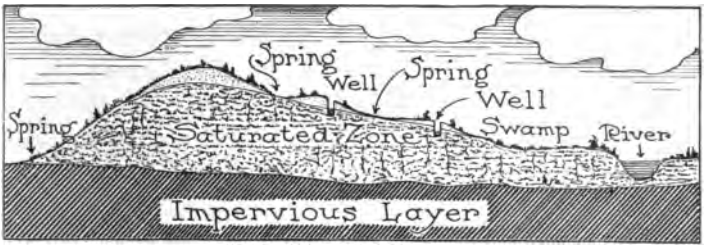


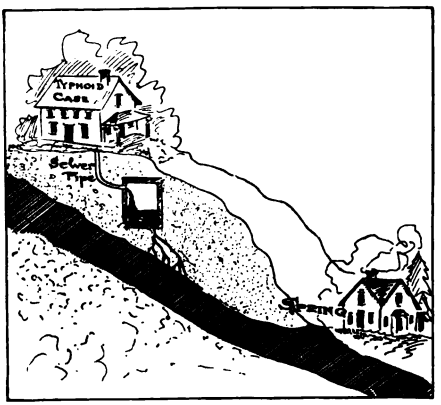
Diagram to show the relation of springs and wells to underground water.

cause rain water to become unfit for drinking purposes. An excellent plan is to have the first water which falls run off without entering the barrel or cistern, because that water is almost sure to contain dust and other impurities. The best type of cistern is a tank of non-porous material placed in the ground.

Springs and wells. — Any boy or girl who has lived in the country knows what a spring is and any one with a little thought can see how a spring might arise from rain water. The rain soaks into the ground until it comes to a layer through which it cannot pass (*impervious layer*). It then seeps along until it acquires pressure enough to flow out. If the saturated zone rises to the surface a spring may result. A glance at the accompanying diagram will show how springs occur. In a gushing spring the water is forced out under pressure. Water which has soaked into the ground at some point far distant, often travels underground between two layers of impervious material, following along some layer of soil or rock which allows its passage, and finally finds its way to the surface through some crack or hole in the hard rock. Artesian wells are made when

such underground water sources have been tapped artificially. Sometimes this water may run underground for a long distance, and come from a much higher altitude, so that when it is tapped it shoots into the air to some height.

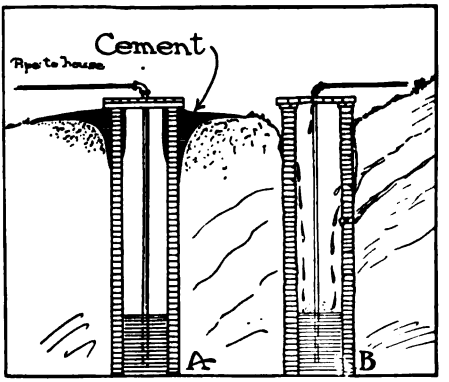
What is impure water? — We usually consider water pure unless it contains something that is injurious to health. Ordinary dirt or mud found in water will not cause illness unless there is decaying organic matter in it. Wherever we find decay, we find germs which cause this decay, so impure water, from a health standpoint, is water containing germs. When we realize that germs of different kinds exist in the food tube of our body, and that the wastes which are passed off are full of germs, then it is evident that water which contains sewage is impure. Any water drawn from the surface of the land would be more likely to contain such wastes, and hence would be more dangerous than water coming from underground.



A spring located like this one is deadly. Are there any such in your locality?

Safe wells and deadly ones. — Many of us who have visited the country on our vacations remember with pleasure the cold water from the deep well or hillside springs near the farm house. Look at the picture and see how a spring may be polluted by a cesspool. We have all doubtless seen places where the well

water might be a source of danger, for all the wastes from the house sinks, from the barnyard, and from the privy or cesspool might soak into the well and render it impure. Could you really determine a safe place for a well without knowing something of the rock and soil under the house and grounds? Drainage from the soil may mean that impurities reach the well. We must also protect the well from the surface drainage. Study the picture of the two wells shown here, and explain why the building of a concrete parapet which slopes away from the opening of the well will protect the water in the well. In addition to surface protection, we should know how the land drains so as to be sure that the well is safe. If one is uncertain as to the purity of the water, a sample can be sent to the town or state bacteriologist, to determine whether the water is safe to drink. This should be done in any case where you suspect that the water is not pure. A *driven well* on a slight elevation, when the pipe is driven deep into the soil and situated at least 100 feet from a cesspool, or barnyard, will in ordinary sandy soil give pure water. This makes a particularly safe well.

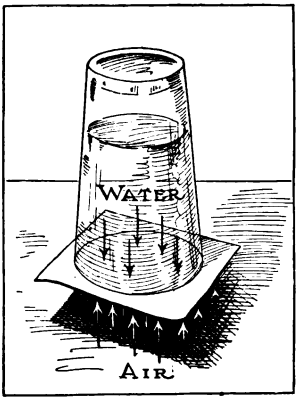


Would you choose your water supply from *A* or from *B*?

How we get water into our houses. — This is a problem that the city dweller does not think much about, because

water is delivered directly to his home through pipes. The problem of city water supply will be taken up later. It is sometimes quite easy for the country house to have running water simply because water is pulled down by gravity, or "runs down hill." If the spring or source from which the water is taken is above the height of the house, it can be piped into the house easily; if the well or spring is below the house we have a different problem.

If the country boy or girl acquires a little knowledge of air pressure, it might enable him or her to plan how to make use of this knowledge to deliver water into the house. We have already seen that air has weight. If you take a tumbler of water, place a smooth card over the tumbler and then invert it carefully, you can lift the glass upside down with the water in it. A moment's thought will tell you that something is pressing upward on the card, or that the air pressing against the card weighs more than the water held in the glass. If you take a wide-mouthed bottle, fill it with water, insert a cork containing a glass tube, and then try to suck the water out you will be unable to do so. Loosen the cork a little and then try, and you will find that you can suck the water out. We may demonstrate this same principle in another way.

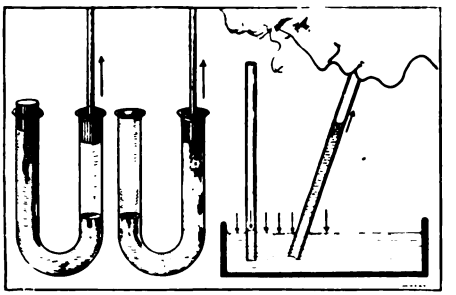


The water is held in the glass by the upward pressure of the air.

Experiment. — To show how air pressure can lift water.

Materials: A U-tube, piston, and stopper to fit, a glass tube.

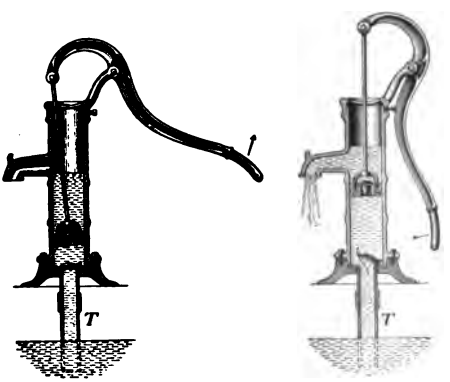
Method and Results: (*a*) Fill the U-tube with water. Push the piston three fourths of the way down one side of the U-tube. Place the stopper in the other end, making sure that it is air-tight. Pull the piston to the top of the tube. Result? (*b*) Repeat (*a*) and leave the end of the tube open. Result?



Conclusion: Explain why the water follows the piston to a higher level in one case than in the other.

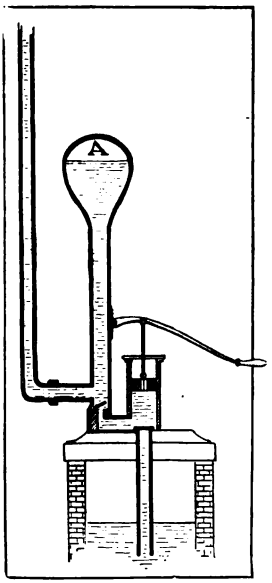
Application: If the tube were straight and dipped into a jar of water, would the water follow the piston? Explain. Explain how one can drink soda water through a straw.

Let us apply this principle to the pump. If the tube is placed in the water as in the diagram and we suck on the tube, we can pull the water up. This is because we have removed the pressure of the air in the tube and this allows the air outside the tube to force the water up the tube. If we now substitute for the tube the pump, consisting of a piston (see diagram) containing a lifting valve, we see that when this piston is raised the water is pushed into the tube by the weight of the air pressing down on the water



The lift pump.

in the cistern. When the piston is lowered the valve in the piston opens, thus allowing the water to run into the space above the piston. On the next upward stroke of the piston this water which is held above is lifted still higher in the tube until eventually it flows out of the pump. This pump, known as the *lift pump*, will only raise water to a height of about 33 feet because the weight of the air, which presses down with a force of fifteen pounds to the square inch upon the surface of the water in the cistern, can balance a column of water only 33 feet high. In practice the lift pump will rarely lift water more than 28 feet because of leakage around the piston and valves.

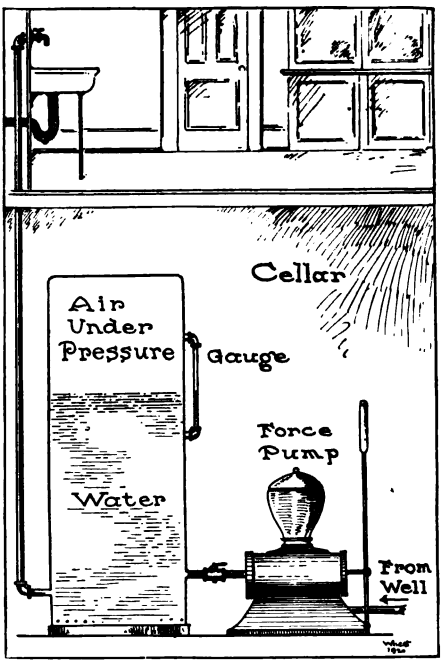


The force pump.

If we wish to force water above twenty-eight feet we use a *force pump*. This is illustrated in the accompanying diagram. Study it carefully and explain why we are able to raise water higher by this method than by the lift pump. Chamber *A* holds air which may be compressed in order to give a continuous flow of water. Can you explain how it does this?

The pneumatic tank system. — In some houses a supply system by which water can be piped and sent to all parts of the house is used. This can be done through the use of a *pneumatic tank*. (See illustration on page 83.) Water is forced into the tank and the confined air above it is com-

pressed so that it exerts great lifting power. Thus when the tank is three fourths full of water the air is compressed to one fourth of its original volume and the pressure becomes four times that of the atmosphere, or four atmos-



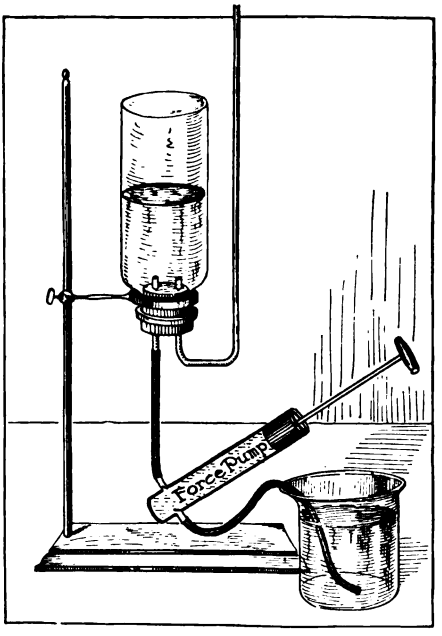
Pneumatic tank system of distribution of water.

pheres. Such a pressure will easily force water higher than the top of an ordinary house.

Experiment. — To demonstrate the use of the pneumatic tank.

Materials: An eight-ounce, wide-mouth bottle. Two-hole rubber stopper. Glass tubes. Force pump. Ring stand. Rubber tubing.

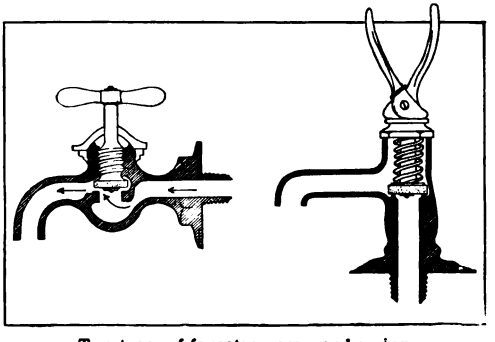
Method: Invert the bottle and support it on the ring stand. Make a U bend at one end of a four-foot glass tubing. Insert this in the rubber



stopper. One end of the other glass tube is connected by a rubber tubing to the outlet valve of the force pump. The inlet valve of the pump is connected by a rubber tubing to a jar of water. Wire the stopper securely in the mouth of the bottle. Pump water into the bottle, and as it presses the air, note how high it rises in the glass tube. Connect another four-foot length of glass tubing on top of the first one. When the water fills one fourth of the bottle, what is the height of the water in the tube?

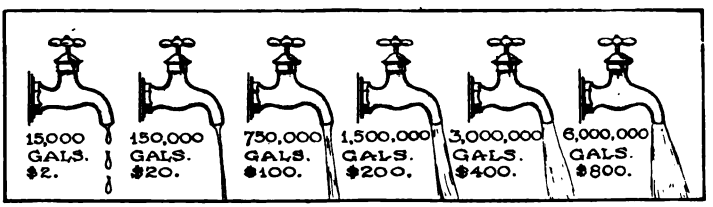
Application: Apply this principle to a house supply. How high could the water be raised if the air in the bottle were compressed to half its original volume?

Faucets. — Any water system in the house means that we must have pipes that carry the supply from where the water enters the house to the kitchen, to the laundry tubs, to the bathroom and toilets. A cut-off valve is placed



Two types of faucets: screw and spring.

close to the point where the water enters the house. Why? In order to obtain water when we wish it a device called the *faucet* is necessary. A careful study of the two diagrams will show how these devices are operated. The type most in use is known as the screw faucet. In this type, as the handle is screwed down, a washer, which may be a round perforated disc of rubber, is forced down over the opening where the water flows, thus making it water-tight. In another common type of faucet, the pressure of a spring (see diagram) holds the washer down so that no water can



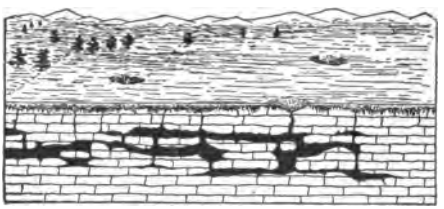
Water waste per year.

get out. When we squeeze the handles together, this pressure is released and the water flows through.

How to stop faucets from dripping. — Any handy boy, or girl either, for that matter, should know how to stop faucets from dripping. The first thing to do is to turn off the supply of water at the cut-off in the cellar, then with your wrench take off the handle of the faucet and remove the washer. You will probably find the washer either broken or badly worn. A new washer which can be procured at any hardware store should then be inserted and the handle replaced. Sometimes a faucet when turned on gives an annoying noise, due to vibration as the water passes through. If caused by a loose washer it is easily remedied. Leaky faucets waste money; do not allow any of them in your home.

What we mean by solution. — You are all aware of the fact that sugar placed in your lemonade soon dissolves in it and disappears, but you can taste the sugar in all parts of the glass of lemonade. If you were to allow crystals of eosin (the material from which red ink is made) to dissolve in a bowl of water, in a short time the eosin would have passed to all parts of the water, giving it a uniform pink color.

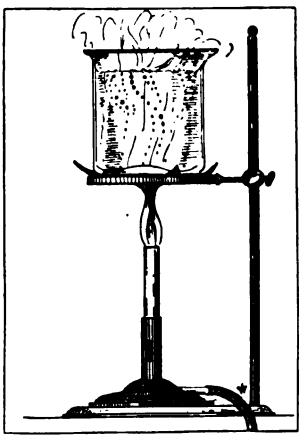
When a substance completely dissolves in a liquid so as to become permanently a part of it, we say the substance is *soluble* in water, and that we have a solution. Water takes up mineral matter in solution. Rain water, although perfectly pure as it drops from the clouds, after soaking into the ground may soon take up into itself mineral matter by solution. Certain minerals, particularly compounds of calcium (lime) and magnesium, are slightly soluble in ground water, and indeed in some parts of the country, great gaps and caves have been formed by water gradually running through limestone and dissolving it out. We must not confuse solutions with muddy water, for if we allow a glass of muddy water to stand, the mud eventually settles to the bottom, or if the water is passed through filter paper, it remains on the filter; but when mineral substances are in solution, they pass through the filter with the water.



Formation of caves by water running through limestone.

Hard and soft water. — Water that has taken up a considerable amount of soluble mineral material is called hard

water, while rain water and other waters that have little or no dissolved mineral matter in them are known as soft waters. We can usually tell hard water because soap does not readily make a good lather, or suds, with it. We find that the soap comes to the top in a sticky, insoluble scum. Hard water leaves a deposit in kettles, feels harsh to the hands, and requires much washing powder, else it is very wasteful of soap. Such waters are perfectly good to drink, but must be treated with chemicals before using them for washing purposes. Washing soda added to the water before soap is used will usually make the water better suited for washing.



Notice the bubbles of air which escape when water is first heated. Why is boiling water sometimes recommended?

How we may make water pure. — We have already seen that harmful water contains germs. Germs are living organisms, and many of them do harm when they are alive. Any method which will kill them and will not harm the water will therefore render it safe to drink. Boiling water for a period of at least ten minutes will kill practically all harmful germs, so that we may safely drink such water. Unfortunately, boiled water has a flat and unpleasant taste, due to the fact that the air which was held in solution has been forced out of it. In order to make such water palatable we may shake it up in a bottle half full of air or allow it to stand exposed to the air. Such water dissolves some of the air and again assumes its palatable taste, and is good to drink.

SCORE CARD. WATER IN MY HOME

	Excellent	Fair	Very Poor	My Score	
					Total
A SAFE WATER SUPPLY	Water protected from surface drainage (deep) (5)	Water from shallow source protected against surface drainage (3)	No protection from drainage. Cesspool or privy within 100 ft. (0)	....	
	Water without sediment (1)	Water having some sediment (½)	Much sediment (0)	....	
	Water having no color (1)	Water having slight color (½)	Much color (0)	....	
	Water having no odor (indication of organic matter) (2)	Water having slight odor (1)	Much odor (0)	....	
	Use of bottled water for drinking (1)	Boiled water for drinking (1)	Neither boiled nor bottled water used for drinking (0)	....	....
AMPLE WATER SUPPLY	Always enough water for all purposes at all seasons including possible fire (5)	Supply only to two lower floors of home (3)	Supply only to lowest floor of house (2)	....	
	Head of water sufficient to throw stream over house (5)	Supply sometimes low in hot summer or cold winter (3)	Supply usually low in winter or summer (1)	....	....
ALL PARTS SUPPLIED WITH PIPING AND FIXTURES	Water supplied under pressure to bathroom (1), toilet (2), sink (1), and tubs in kitchen or laundry (1)	Water supplied under pressure from pneumatic tank to bathroom (1), toilet (2), sink (1), tubs (1)	Pumps: no pneumatic tank. Water supplied only to sink (1), tubs (1)	....	....
	No pumps: gravity system: piped to all parts of the house (5)			....	....
CONDITION OF PLUMBING	Pipes in good condition; no leaks (2)	Pipes in fair condition; sometimes leak (1)	Pipes old and leaky (0)	....	....
	Faucets all tight; no dripping (2)	Faucets drip at times (1)	Faucets constantly drip (0)	....	....
	Pipes never freeze (2)	Pipes freeze in very cold weather (1)	Pipes freeze in ordinary winter weather (0)	....	
	Plumbing all exposed (2)	Plumbing partly exposed (1)	No exposed plumbing (0)	....	
	No odors (2)	Slight odor at times (1)	Much odor from plumbing (0)	....	....
SOFT WATER PROVIDED	Water is soft (4)	Water of medium hardness (2)	Water very hard (0)	....	
	Rain water and cement cistern (3)	Rain water in tightly covered barrel (1)	Rain barrel exposed, no tight cover (0)	....	
	Bucket pump or other means of mixing air with water (2)	Water falls from height into barrel thus mixing air with it (1)	No method of mixing air in water (0)	....	
	Flow-off of first rain water from roof (1)	Roof clean, waterproof paint (1)	Water smells or is dirty (0)	....	
GRAND TOTAL					....

Scoring my home water supply. — Any boy or girl who has read this chapter with thought now realizes the importance of our water supply and how great an advantage those of us who live in cities have over those who have no safe supply or to whom it is not delivered in pipes. The score on the preceding page will probably be much higher for those who live in the city.

REFERENCE BOOKS

Barber, *General Science*, Chapter IX. Henry Holt and Company.
Broadhurst, *Home and Community Hygiene*, Chapter V. J. B. Lippincott Company.
Butler, *Household Physics*. Whitcomb and Barrows.
Caldwell and Eikenberry, *General Science*, Chapter IX. Ginn and Company.
Clark, *Introduction to Science*, Chapter XXXIV. American Book Company.
Hazen, *Clean Water and How to Get It* (Teacher's use). John Wiley and Sons.
Hoadley, *Essentials of Physics*. American Book Company.
Hunter, *A Civic Biology*, Chapter VI. American Book Company.
Lynde, *Physics of the Household*. The Macmillan Company.
Ritchie, *Primer of Sanitation*, Chapter XX. World Book Company.
Smith and Jewett, *Introduction to the Study of Science*, Chapter V. The Macmillan Company.
Yearbook, U. S. Dept. Agri., *Clean Water and How to Get It on the Farm*.
Weed, *Chemistry in the Home*, Chapter III. The American Book Company.

CHAPTER VI

THE USES OF FOODS

Problems. — 1. *To learn the uses of foods.*

2. *To learn of what our bodies are made and what must be supplied if we are to grow.*

3. *To learn to tell what different nutrients foods contain.*

4. *To learn how and where food is made ready for absorption.*

5. *To determine reasons for differences in diets.*

6. *How to select a proper and economical variety of food.*

7. *How and why foods should be cooked.*

Experiments. — 1. To show the presence of carbon and water in foods.

2. To make tests for the carbohydrate foods, sugar and starch.

3. A test for protein.

4. A test for fat or oil.

5. To show digestion of starch with saliva.

Project I. — WHAT NUTRIENTS ARE IN THE FOODS COMMONLY USED IN MY HOME?

1. Make a list of the common foods used.

2. Test some of these for starch, sugar, fat, and protein.

3. Consult food tables in books to learn the proportions of the different nutrients and their fuel value in foods.

Project II. — TO OBTAIN STARCH FROM POTATOES.

1. Look up a method or device by which you can separate starch granules from potatoes.

2. Prepare an exhibit to show what you have done. You might show:

(1) Potatoes equal in weight to those used.

(2) The starch you obtained.

(3) The residue.

(4) A chart comparing your results with the actual amount of starch in potatoes as learned from food tables.

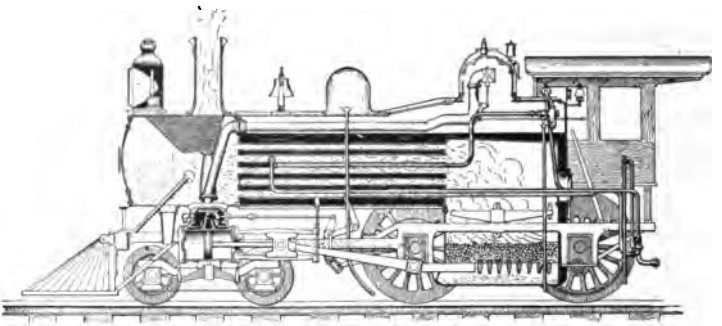
(5) A written report of your work and results including an account of starch factories, possibly illustrated with pictures.

Project III. — TO PLAN FOR ECONOMICAL BUYING FOR OUR FAMILY FOR ONE WEEK.

1. Determine foods and amounts of each.
2. Determine proportion of different nutrients needed.
3. Compare costs.
4. Purchase cheaper foods giving required nutrients.
5. Make a written report comparing your purchases with those of the previous week. Give your conclusions before the class.

Comparison of the human body with an engine. — We have already compared the human body to an engine. Let us go farther with this comparison. It is like an engine in that it contains very many complex parts, each of which has some particular work to do; for example, the fire box, or steam chest of the engine, or the carburetor of a gasoline engine, or in the case of the human body, there are the lungs and passages leading to them, the food tube with its different complex parts, and the system of blood tubes and the blood within. We find, moreover, that an engine and the human body both work more or less automatically, although the locomotive is controlled from the outside, while in the body control comes from within. Both engine and body need fuel in order to do work. In order to release the energy locked up in the fuel, we must have oxygen to unite with it. Both engine and body must

get rid of the waste material, for no engine can run with its fire box clogged with ashes, nor can any human being live long without getting rid of wastes. Neither engine nor body can be overworked without breaking down. Rest has been found to be necessary for metals as well as for man. It is necessary to allow the most smooth-running



Fuel gives heat and energy, and makes motion possible. (After Hoadley.)

machine to take a rest now and then if the machinery is to be kept in good condition.

But the human machine differs from the engine in some respects. It has the remarkable ability to build itself out of the very materials that are put into it as fuel. No engine could do this. Besides, as we have already seen, germs may attack the human body and render it unable to carry on its regular work. Owing to the activity of these germs, we become ill.

What the body is made of. — If we study the figure on the next page, we find that the human body is made up of about 72 % oxygen, 13.5 % carbon, 9 % hydrogen, 2.5 % nitrogen, about 3 % of various mineral salts, including calcium, phosphorus, potassium, sulphur, sodium, chlorine, magnesium, iron, and some others. All of these substances

mentioned are known as *chemical elements*. The first four named, oxygen, carbon, hydrogen, and nitrogen, are the ones which are of most interest to us just now, as they form the bulk of most foods. Carbon, oxygen, hydrogen, and nitrogen, for example, come to us in such foods as meats and vegetables. Water supplies much of the hydrogen and oxygen. One experiment which can easily be performed at home will show some of the elements contained in foods.

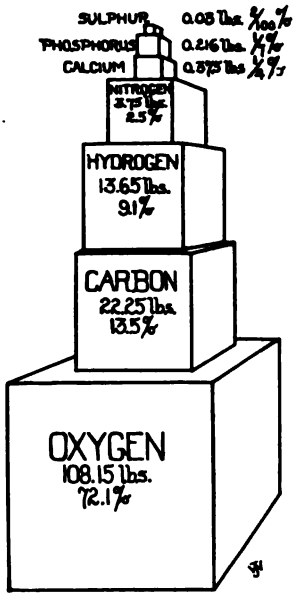


Chart to show the percentage of chemical elements in the human body.

Experiment. — To show presence of carbon and water in foods.

Materials: Several foods, as potatoes, meats, oatmeal. A metal plate or small piece of sheet metal. Burner. Glass funnel. Sugar. Sulphuric acid. A 500 cc. beaker.

Method and Results: Place a small piece of the food to be tested upon the metal and heat it. Hold the glass funnel over it as a test for escaping moisture. Continue heating until a black residue is left. What in all probability is this black substance?

Strong sulphuric acid has such attraction for water that it will withdraw the water from many plant products and generate enough heat to separate it from the black carbon. This is very strikingly done with sugar. Mix 60 grams of sugar in 45 cc. of water in a 500-cc. beaker which is set on a plate. Pour 60 cc. concentrated sulphuric acid into the sugar solution. Result? (If performed as an individual pupil experiment use one fourth quantities suggested.) Can you name the black product?

Some of these chemical elements, although present in very small quantities, have extremely important uses;

for example, it has recently been discovered that the beating of the heart, the contraction of working muscles, and the ability of our nerves to send messages depend upon the presence of very minute quantities of calcium, magnesium, potassium, and phosphorus in the body.

Two uses of foods. — Scientists have shown us that our common foods are made up of substances called *nutrients*. These nutrients are known as proteins, fats, carbohydrates, mineral matter, and water. Three of these nutrients, *protein*, *fat*, and *carbohydrate*, are consumed in the body to release energy. The mineral matter serves to aid in the making of bone, in carrying on digestion, and in other body functions, while the water is largely used as a vehicle to carry the nutrients, and forms a very large percentage of the human body. Protein, of which eggs, lean meat, and the germ or gluten of wheat are examples, is used for making body material. The following table taken from a government bulletin[1] sums up the uses of the nutrients to man.

THE FUNCTION OF THE NUTRIENTS IN THE BODY

Protein . . . . . White of eggs (albumen), curd of milk (casein), lean meat, gluten of wheat, etc.	Forms tissue (muscles, tendon, and probably fat).	All serve as *fuel* and yield *energy* in form of heat and muscular strength.
Fats . . . . . Fat of meat, butter, olive oil, oils of corn and wheat, etc.	Form fatty tissue.	
Carbohydrates . . . . . Sugar, starch, etc.	Transformed into fat.	
Mineral matter (ash) . . Phosphates of lime, potash, soda, etc.	Aid in forming bone, assist in digestion, in absorption and in other ways help the body parts do their work.	

Water is used as a vehicle to carry nutrients, and enters into the composition of living matter.

[1] Adapted from Atwater, *Principles of Nutrition and Nutritive Value of Food*, U. S. Department of Agriculture, 1902.

Where the nutrients are found. — Carbohydrates form the chief nutrient in the foods we call cereals, breads, cake, fleshy fruits, sugars, jellies, and the like. Fats and oils are found in nuts and some grains, and make up the greater part of bacon, pork, lard, and butter. Animal foods yield our chief supply of protein. White of egg and lean meat are almost pure protein and water. Proteins are most abundant in those plants which are richly supplied with nitrogen such as peas and beans, grains and nuts.

Carbohydrate foods.

Foods rich in protein. (After Tolman.)

How to test for the nutrients contained in foods. — Since it is necessary for us to have some or all of these various nutrients in our daily diet, it will be interesting for us to learn how to determine their presence in foods. An interesting home experiment is the testing of as many of the foods which make up your daily dietary as you can.

Experiment. — Tests for the carbohydrates, sugar and starch.

Materials: Starch. Grape sugar. Iodine solution. Fehling's solution. Test tubes. Various foods to be tested. Bunsen burner.

Test for Starch: Mix a little starch with cold water and heat to boiling in a test tube. Add a few drops of iodine solution. The resulting blue or blue-black is the characteristic test for starch. The test may

be made on cold starch, but is quicker and surer if the substance tested has been heated to the boiling point. The heat causes the granules to swell and burst the cell walls which inclosed them.

Test for Grape Sugar: Place a little grape sugar in a test tube one fourth full of water. Add an equal amount of Fehling's solution. Heat to the boiling point. The characteristic brick red color which appears is the test for grape sugar. Cane sugar heated or digested with diluted acid changes in part to grape sugar, but pure cane sugar will give no result with this test.

Test many foods, as oatmeal, bread, potatoes, rice, sirup, molasses, cabbage, apples, bananas, candy, cheese, meat, etc., for starch and sugar. List the foods under the following headings:

Much Starch	Little Starch	No Starch	Grape Sugar

Experiment. — To test for fats or oils.

Materials: Pork or butter, oily nut, corn meal, paper.

Method and Results: Rub a piece of pork or butter on a piece of paper. Lay a crushed nut or a little corn meal on a piece of paper and place it in a warm oven for a few minutes. The oil or fat absorbed by the paper makes a semi-transparent spot which is seen when held toward the light.

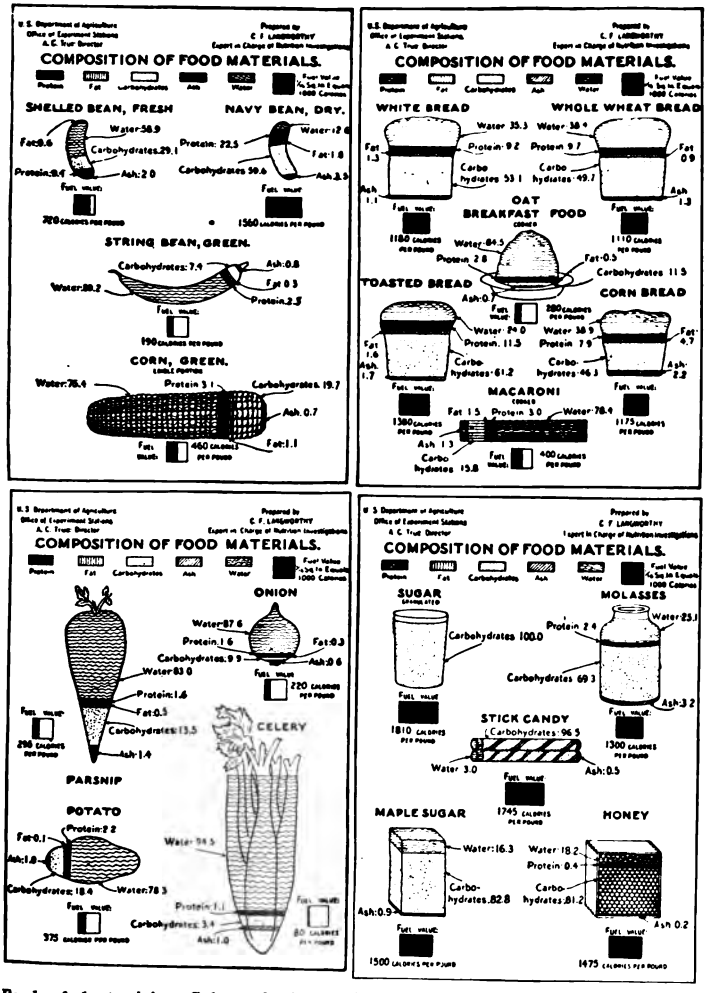
Application: Test various foods. Those which give a test without warming in the oven have a higher per cent of fat.

Experiment. — To test for protein.

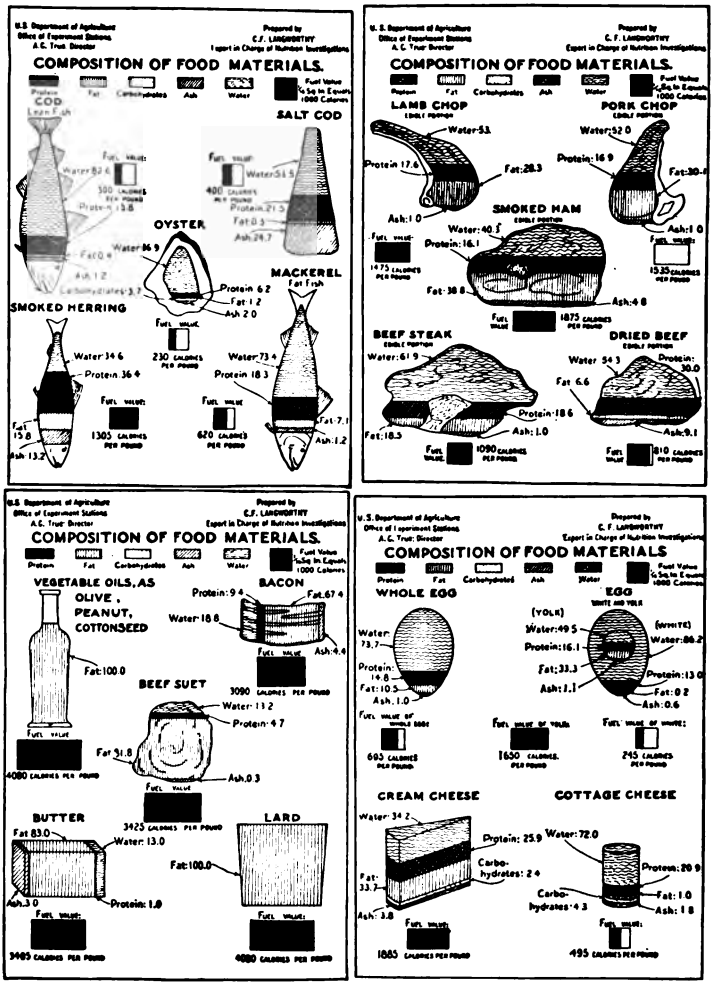
Materials: White of egg (a typical protein). Test tube. Concentrated nitric acid. Ammonia.

Method and Results: Pour the white of egg into boiling water to coagulate it. Pour off the water and add a few drops of strong nitric acid to the solid white of egg. Is there any change? Rinse the acid off with water and add ammonia. The lemon color after the addition of the acid and the deep orange following the addition of the ammonia complete the test for protein. Heat quickens the reaction.

Application of Test: Try this test on such foods as lean meat, bread, cheese, beans, and rice. Which ones show the presence of protein?



Foods of plant origin. Select 5 foods containing a high percentage of protein, 5 with a high percentage of carbohydrates, 5 with a high percentage of water. Do vegetable foods contain much fat? Which of the above-mentioned foods have the highest burning value?

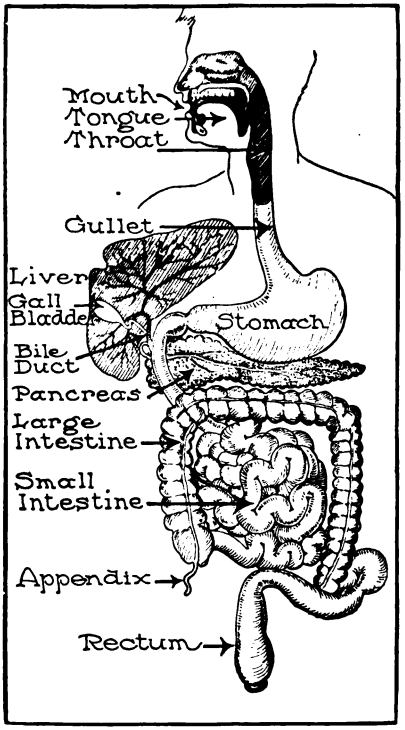


Foods largely of animal origin. Compare with the previous chart with reference to amount of protein, carbohydrate, and fat in foods. Compare the burning value of plant and animal foods. Compare the relative percentage of water in both kinds of foods.

The food requirements of the body. — For some time chemists have had a standard of measurement for heat given off when substances are burned. This heat unit is called a calorie. A calorie is the amount of heat required to raise the temperature of one pound of water from zero to four degrees, Fahrenheit. The burning value of foods may be determined and measured in calories. Professor Atwater and others, by means of a series of interesting experiments, endeavored to show how much *fuel* is needed by our bodies each day, as well as the amount of *building material.* It has been found, for instance, that the human body needs from three to a little over five ounces of protein each day, and enough fuel food to furnish the body with from two thousand to six thousand calories. We may adopt as our standard proportion of nutrients 1 (protein) : 1 (fat) : 4 (carbohydrate). Stated in another way this is about a quarter of a pound of protein, a quarter of a pound of fats, and a pound of carbohydrates each day for a person doing moderate work. More food would be needed if hard work had to be done.

How foods are prepared for use in the body. — We all use foods, but the body does not use them in the condition in which we buy them. If we think for a moment, we will remember that food, in order to become a part of the body, has to pass through the wall of the food tube and get into the blood, and from there be carried to the place where it is to be used. You cannot pass a solid material through a thick wall. Obviously, the food tube has in some way to change the materials from solids into liquids so that they can get through this thick wall. This process of changing foods into a liquid condition which enables them to pass through the walls of the food tube and become part of the blood is called *digestion.*

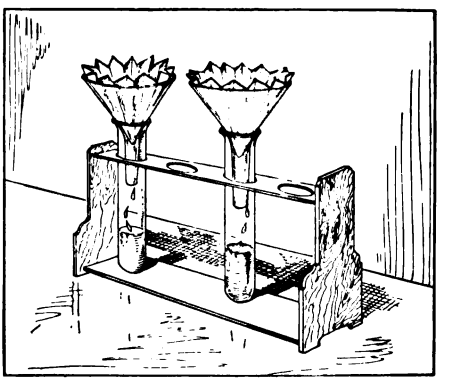
Where digestion takes place. — If we study the accompanying diagram of the *digestive tract* we notice that there are several parts to it: the mouth, with the tongue, teeth, and three pairs of salivary glands, which produce saliva in the mouth. Beyond the mouth a smooth muscular tube, known as the gullet, which leads to a bag-like organ, called the stomach. Some people think the stomach is the organ of digestion, but it does only a part of the work of digestion. The stomach opens into the small intestine, which in the adult is a much coiled tube about thirty feet in length. In this tube most of the digestion takes place. Into this part of the tube are poured juices from two large glands, the pancreas and the liver. The wall of the small intestine is thrown into thousands of little projections, called *villi*, through which the digested food is absorbed into the blood. The large intestine is the last part of the food tube. Near the junction of the small and the large intestine is a little sac, the *vermiform appendix*, about which most of you



Digestive tract.

know. This is an organ of much harm and little use, because of the disease appendicitis which results from its inflammation.

How digestion takes place. — It is not so easy for us to understand how solid foods are made liquid in the food tube, but perhaps the following experiments will help. If we take unsweetened cracker and chew it for some time, we notice it begins to taste sweet. A cracker is composed largely of starch. Mix some powdered cracker, or starch, with a small quantity of water. Pour this mixture into a funnel lined with filter paper, and allow the substances to trickle through into a test tube. Take grape sugar of equal weight with the starch. Mix with as much water as before and filter in like manner. We can prove that no starch comes through the filter. If we test the water that drips through with iodine, it does not turn dark blue. If we taste the water which has dropped through from the funnel containing the sugar, we find it is sweet. Evidently sugar passes through this wall, while starch does not. An experiment performed with unsweetened crackers shows that mixing a cracker thoroughly with saliva causes some of the starch to change to grape sugar (a kind of digested starch) while cracker moistened with water will not be changed. This



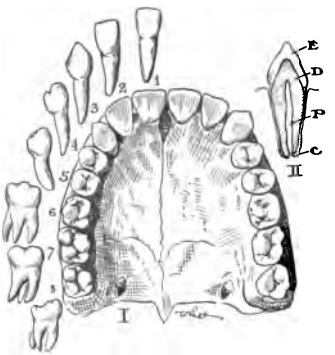
What does this experiment prove?

change, or digestion, is caused by the presence in the saliva of a digestive ferment called an *enzyme*.

Experiment. — To show digestion of starch with saliva.

Add a few drops of sodium carbonate solution to a test tube a third full of starch paste. Add a tablespoonful of filtered saliva warmed to 99 degrees F. Keep it at this temperature on the water bath. At the end of ten minutes test a portion of the solution with Fehling's solution to see if any of the starch has been changed to sugar. Result?

Enzymes and what they do. — We shall find in our later study that enzymes perform an important work in the body of plants and animals. They are the active parts of the digestive fluids and cause the digestion of the nutrients in different parts of the food tube. Starches are digested in part by enzymes supplied in the mouth, and in part by other enzymes in the small intestine. Proteins are digested by enzymes in the stomach and intestines. In the small intestine fats are changed in part by enzyme action into a kind of soft soap, in which form they enter the blood.

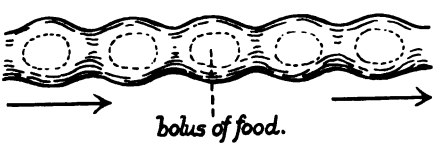


I. Teeth of the upper jaw, from below. *1, 2,* incisors; *3,* canine; *4, 5,* premolars; *6, 7, 8,* molars. II. Section of a tooth. *E,* enamel; *D,* dentine; *C,* cement; *P,* pulp cavity into which blood vessels and nerves pass to keep the tooth alive.

The uses of the teeth. — If you study the accompanying diagram of the teeth, or better, your own mouth before a mirror, you will notice that some teeth are broad and rather irregular on the upper surface, and are evidently used for grinding. Others are sharp or pointed, and are

used for cutting or tearing. The long tooth of a dog is an excellent example of a tooth fitted for tearing purposes. Using the diagram, divide the teeth according to their uses, and name them from the chart, as — molars, premolars, canines, and incisors. The teeth, with the assistance of the tongue, prepare the food for digestion by cutting and crushing it, so that when the tongue pushes it into the gullet, it will be in better condition for digestion. The smaller the particles of food the more surface the enzymes have to act upon, and consequently the more rapidly digestion takes place in the body. There is, then, a real scientific reason for chewing the food.

Movement of the food tube as an aid to digestion. — Perhaps you have had the experience of losing something held in the mouth by having it slip down the food tube without your being able to get it back again. As this mysterious movement of food through the tube takes place just as well when we are lying down as when we are standing up, it is evidently not due to the force of gravity. The walls of the gullet, the stomach and small intestines are muscular, and are constantly in motion. The stomach itself aids more than the teeth in making the particles of food smaller, for the food after it is swallowed is turned over and over again by the action of this muscular organ, and only very small particles are allowed to go into the small intestine. The large intestine sends along the food by means of wavelike movements. This movement, called *peristalsis*, occurs in both small and large intestines and is of great importance



Peristaltic waves.

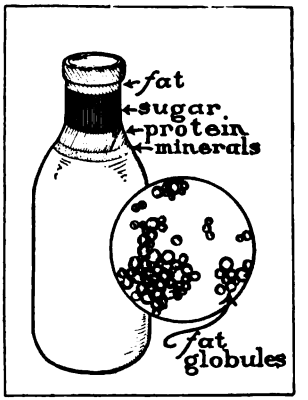
in passing foods through the food tube and in expelling wastes from it.

The influence of the mind on digestion. — Not many years ago, it was discovered in experiments with the X-ray machine that the peristaltic movements of the food tube were stopped or arrested when a cat or a dog was frightened or angry, but when contented and happy the movements began again and continued normally. These experiments teach us a very real lesson, for our own food tube acts in the same manner. Form the habit of contentment. At meal times especially learn to be cheerful and happy. Laugh and grow fat is a statement founded on simple scientific fact.

Some reasons for differences in diets. — It goes without saying that you would not fill up the fire box of your furnace with as much coal on a day that promised to be warm as on a cold day. Similarly we do not always need the same amount and kind of food. A man doing hard work, for example, would need very much more energy-giving food than a man doing little work.

We find that environment plays a very important part in diet. People living in hot climates need different foods from those in cold climates. The inhabitants of cold countries need more heat-releasing foods, and use fats for this purpose. In summer we do not require so much fat as we do in winter, and watery foods, such as fruits, vegetables, milk, eggs, and cereals, are better than much meat and fats. Age should cause a difference in the kind of food. We take food in order to make new body material, to repair what is wasted, and to give us energy. Very young children grow rapidly, and should use milk largely in their diet. A study of the diagram will show you the reason for this.

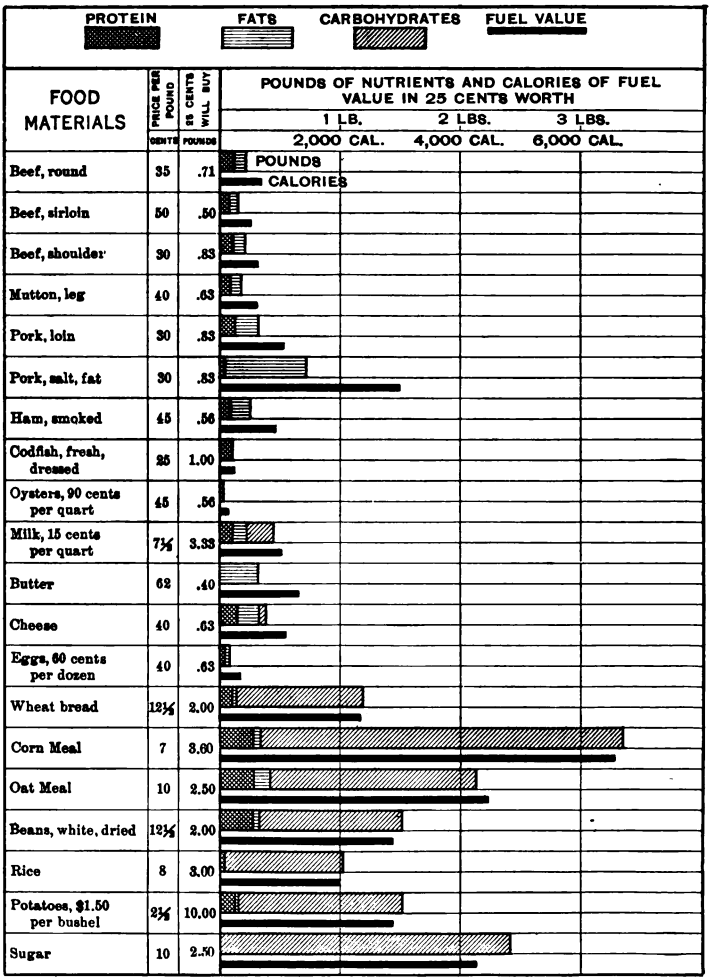
Milk contains all the food nutrients, and in about the right proportion for a child. Rapidly growing boys and girls require more food, and more protein food than do those who are older. As a rule boys and men need more food than girls and women.



Composition of milk. What per cent is water?

Each one of us must determine also whether he or she can easily digest certain kinds of foods. Some of us, for example, cannot eat strawberries or tomatoes without suffering from indigestion, while some of us are able to eat these foods, but cannot take others, for "what is one man's meat is another man's poison."

Food economy. — A study of the table on page 106 will show us that the same amount of money will buy vastly different amounts of energy and building material in food. The American family, as a rule, does not expend its money wisely in foods. We should eat to live, and not live to eat. We should learn to like and use cheaper foods which have the same nutritive value as do the more expensive ones, and above all we should learn to eat more fruits, more vegetables and cereals, more milk, and less meat, because meat is more expensive, and because there is danger of eating too much protein. We Americans are fond of meats, and eat more than is good for us. As a result we make some of our organs work overtime and put a strain upon them in order to get rid of the extra protein which forms wastes harmful to the body.



On the basis of cost and food values shown in the above table, make an economical dietary for one day for a man engaged in light work. Make a second dietary to satisfy the same conditions but select expensive foods. Give reasons for the amounts and choice of foods in each case. What is the difference in the cost of these two dietaries?

Vitamines and their uses. — Recent studies have shown that some foods possess peculiar substances known as *vitamines* which are essential to health. For example, one of

These rats are the same age. They were always fed the same kinds and amounts of food, namely, bread 60%, potatoes 20%, greens 20%, but the one at the left had in addition a tablespoonful of milk daily. (Photo from Battle Creek Sanitarium.)

the German raiders was forced to put in at Newport News and have its crew interned because of severe illness among them. They seemingly had all the food necessary, for they had sunk ship after ship and had taken canned goods, wheat flour, and other materials in abundance. The officers had fresh vegetables from time to time while the crew had none, and after a period of nearly three hundred days, a large number of the crew became so ill that medical attention was necessary. When these men were given a diet of fresh fruit, milk, eggs, and soups made of boiled skins of vegetables, they were cured in a very short time. This seems to show that they needed the vitamines which were present in skins of certain vegetables. The chief sources of vitamines for us are the outer coats of rice (unpolished or brown rice), potatoes, carrots, and some other vegetables; eggs, milk, and many fresh fruits, particularly oranges and pineapples.

Marketing. — Most mothers and fathers do the marketing for the family, but it would be good practice for girls and boys to do this for one week. They would find it would not be as easy as it seemed, for one must keep in mind that the cost of foods has little relation to their nutritive value and that some foods that cost a great deal have a low nutritive value. They must also remember that the family has need of fuel for the body and building material as well which must be supplied by foods. If you will study the charts on the preceding pages, you will find that all of these factors must be taken into account in buying for the family. An excellent home project would be for each boy and girl to market for one week, and to bring into class lists with amounts and cost of each article purchased. These should be placed in tabular form, giving the size of the family, approximate age of each member of the family, and all other data which would be necessary in order to discuss the material brought in. Class discussion of these lists would then enable you to decide which one of the marketing lists was the best. Why not try this?

How to select a proper menu. — A practical exercise which will enable your teacher and schoolmates to determine whether you have understood the foregoing paragraphs will be to select the proper foods from the three following lists, for breakfast, lunch, and dinner respectively. In preparing these menus, balance the diet, keeping in mind your own occupation, your own age, your own ability to digest foods, and the cost of foods.

What foods could you substitute for meat to get proteins? What articles on the menu might you select because of their good taste, but which do not have much food value? Should such articles be part of our diet? Which

beverages are foods? Which are not? Can you give good reasons for this? In connection with this menu study the food tables and all diagrams given in the chapter.

BREAKFAST

Cantaloupe	Beefsteak	Griddle Cakes and Maple Sirup	Apple Sauce
Oranges	Boiled Egg	Whole Wheat Bread	Apple Pie
Prunes	Fried Lamb Chop	Hot Biscuits	Crullers
Cornflakes	Fried or Hashed Brown Potatoes	Toast	Coffee
Oatmeal	Hominy	Butter	Milk
Shredded Wheat			Tea

LUNCH

Chicken Soup	Shrimp Salad	Bread and Butter	Peaches and Cream
Corn Soup	Baked Beans	Hot Biscuit	Ice Cream
Vegetable Soup	Frankfurters	Soda Crackers	Cocoa Milk
Fruit Salad	Dill Pickles	Doughnuts	Soda Water
Potato Salad	Cheese	Chocolate Cake	Tea

DINNER

Consommé	Boiled Ham with Spinach	Stuffed Peppers	Peach Pie
Clam Chowder	Saddle of Lamb	Hearts of Lettuce French Dressing	Vanilla Ice Cream
Pea Soup	Planked Steak	Lobster Salad	Chocolate Ice Cream
Olives	Mashed Potatoes	Fruit Salad	Grapes
Celery	Baked Potatoes	Waldorf Salad	Nuts
Pickles	Potatoes Lyonnaise	Italian Salad	Raisins
Fried Filet of Sole	Peas	Bread	Edam Cheese
Boiled Whitefish Saratoga Chips	String Beans	Rolls	Roquefort Cheese
Roast Lamb with Brown Gravy	Cauliflower	Butter	Tea
Fried Chicken	Beets	Strawberry Pie	Cocoa
	Rice	Apple Pie	Milk
			Coffee

What cooking does to foods. — If we were to examine a bit of raw potato under the microscope, we would find that the starch contained in it was placed in little pockets surrounded by thick walls. Examination of a bit of cooked potato under the microscope will show quite a different condition. The walls around the starch cells are broken and the starch swelled and softened. Cooking breaks down

Foods Adapted to Different Ages, Classified according to What They Do for the Body

Numbers are placed after some foods to show that they do important work under the column headings of those numbers.

Food Primarily for Growth and Repair		Food Primarily for Heat and Work (Energy)		
I *Rich in Protein* Builds and repairs muscle	II *Rich in Mineral Matter* Builds bone Body activities	III *Rich in Fats* Stimulate growth	IV *Carbohydrates Starches* Yield energy; heat and work	V *Carbohydrates Sugars* Yield energy for heat and work
Foods Suitable for Infants				
Milk — II, III, V human, modified cow's Beef juice — II	Milk — I, III, V Egg yolk — I Orange juice, Prune juice	Cream — I, II used to enrich cow's milk	Gruels — I, II made from oats, barley, whole wheat	Orange juice — II Prune juice — II
Foods to be Added after the First Year				
Milk — II, III, V Eggs — II, III Poultry — II, III Meats — II, III (in limited amounts)	Soups — III, Fruits — V Greens — III Meat broths with vegetables — III	Egg — I, II Cream — I, V Whole milk — I, II, V Butter — II	Breakfast foods I, II Potatoes — I Rice — I Sweet potatoes — II, V	Prunes — II stewed; in puddings Apples — II stewed; baked
Foods Suitable for Any One over Five Years				
Fish — II, III Cheese — II, III Beef — II, III Veal — II Mutton — II, III Pork — II, III Soy beans — II, III, V Peanuts — II, III, IV Beans (dried) — II, IV Lentils — II, IV Peas (dried) — II, IV Nuts — II, III, IV Cereals — II, III, IV Gelatine	Vegetables (green-leaved) Cabbage — raw as a salad, as vegetable Cauliflower Artichokes Tomatoes Egg plant Green peppers (sweet) Cucumbers Onions Beets and turnips — V Radishes Parsnips Watermelon — raw, pickled Cantaloupe Pickles of all kinds Fruits — raw or cooked Food value depends upon amount of sugar added Dried fruits and vegetables	Following fats may be deficient in fat solubles which stimulate growth. Use them in cooking Oleomargarine — II Peanuts — I, II, IV Suet Goose fat Chicken fat Mutton fat Clarified and mixed with suet or cottonseed oil it makes an excellent butter substitute for cookery Salt pork Lard Bacon — I Olive oil Cottonseed oil Peanut oil Corn oil	Chestnuts — II Squash — II Pumpkins — V Bananas — II, V Rice — II *a.* Polished *b.* Rice flour Wheat products — I, II *a.* Flour *b.* Macaroni *c.* Cream of wheat *d.* Shredded wheat Corn products — I, II *a.* Corn meal *b.* Corn flour *c.* Hominy Barley products — I, II Rye products — I, II Oat products — I, II Buckwheat products — I, II Tapioca	All fruits in jam or preserves, and candied or glacé Apples — II Peaches — II Apricots — II Raisins — II Dates and figs — II All jellies Honey — replaces sugar in preserves, candies, and cakes Molasses — replaces sugar in candies and cakes Maple sugar Grape juice — II All candies All sirups Cane or beet sugar Sweet cakes — I, II, III, Sweet desserts

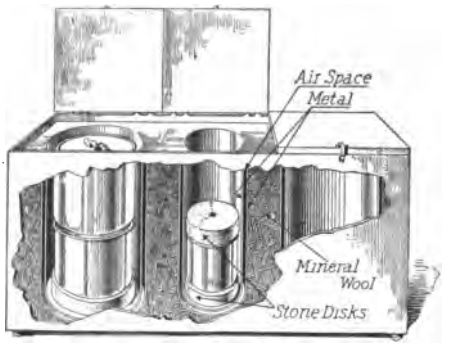
From chart prepared by the Department of Home Economics University of Michigan.

and softens the tough walls of the cells in vegetables, and in the case of meats makes them less tough and renders them more palatable, and thus helps in their digestion. More than this, especially in meats, cooking destroys organisms which might grow if taken into the body. Thus cooking makes foods safe which otherwise might be harmful.

Different methods of cooking. — In general there are four principal ways of cooking foods, boiling, broiling, frying, and baking. In boiling we place the food in water and heat to 212 degrees Fahrenheit. White of egg coagulates or hardens above 140° F. An excellent method of cooking eggs is therefore either to poach them in water just below boiling or to place the eggs in a dish of boiling water, cover, take off the stove and leave for seven minutes. They will be found to be cooked and the white will be quite digestible. Milk should not be boiled, for this injures the protein. In making soups, where we wish to draw the nutriment into the water, the material should be put into cold water, brought to the boiling point, and then boiled slowly. If we wish to keep the nutriment in the material, it should be put at once into boiling water. In roasting and broiling use a high temperature at first. A hot fire should be used in cooking a steak so as to keep the nutriment within the browned surface. A seared covering prevents the escape of juices. Frying is not a desirable method of cooking because fat is likely to soak into the foods, thus rendering them less digestible. In baking, the food should be placed in a hot oven first and then the heat reduced so that the inside of the substances can be cooked. Cooking starch at baking temperature changes it to dextrin, which is more easily

digested than starch. The browning of the bread crust is due to this change.

Fireless cooker. — In these days nearly every household is provided with a labor-saving device known as the fireless cooker. An interesting home project would be the manufacture of such a cooker. The principle of the fireless cooker is that of *insulation*. The food to be cooked is placed hot in the metal container inclosed in a box with heat insulating material filling the space between it and the outer part of the box, while a hot soapstone or cast iron radiator is placed under the container. In this way after the covers are tightly fastened, the food cooks slowly, and its flavor is preserved. In addition to this time and fuel are saved.



Fireless cooker.

Scoring my foods and dietary. — Probably no score card is more difficult for you to use than this one and yet none is more important. If you can make this a summary of what you have learned about the uses of foods and then apply this knowledge in your daily life your time will have been well spent. In this card you will doubtless find important matters that have not been touched. If you want to add or subtract or change any part of the card do so and have the class discuss the change with you, for in this way you may do some real constructive work in science.

SCORE CARD. FOODS IN MY HOME

	Excellent	Fair	Very Poor	My Score	Total
A BALANCED DIET	Menu varies under 10% from 1 (protein): 1 (fat): 4 (carbohydrate)(10)	Variation 10% to 50% (5)	If any one group is omitted (0)	....	....
RIGHT DIET FOR OCCUPATION, SEASON, AND ENVIRONMENT.	More food for heavy work (2) More watery foods in hot weather (1) Less protein in hot weather (2) More fats in cold weather (1) Milk at all times (4)			....	....
FOODS PROPERLY COOKED	Meats broiled, roasted, never fried (2)	Fried meats not more than once a week (1)	Fried meats three times a week or more (0)	....	
	Cereals well cooked (2)	Uncooked prepared cereals (1)	No cereals (0)	....	
	Vegetables boiled slowly in little water (2)	Vegetables boiled rapidly but done (1)	Vegetables undercooked and rapidly boiled (0)	....	
	Puddings, no fried desserts or pies (2)	Fried desserts infrequently (1)	Fried desserts frequently (0)	....	
	Raw foods thoroughly washed (2)	Raw foods usually washed (1)	Raw foods never washed (0)	....	....
COST OF FOODS CONSIDERED	Expensive cuts of meat omitted (2)	Expensive cuts of meat once a week (1)	Expensive cuts of meat every day (0)	....	
	Vegetables out of season omitted (2)	Vegetables out of season twice a week (1)	Vegetables out of season regardless (0)	....	
	Cereals and canned vegetables used when fresh ones are high (2)	Canned goods but never cereals substituted for fresh vegetables (1)	No substitutes for fresh vegetables (0)	....	
	Cheap fruits used (2)	Expensive fruits infrequently (1)	Expensive fruits often used (0)	....	
	Home produced foods used (2)	Home grown foods infrequent (1)	Home grown foods never used (0)	....	....
EASILY DIGESTED FOODS SELECTED	Foods selected every day for vitamines (1)	Foods sometimes selected for vitamines (½)	Foods never selected for vitamines (0)	....	
	Fruit on menu twice a day (2)	Fruit on menu once a day (1)	Fruit infrequently on menu (0)	....	
	Milk on menu three times a day for children under 15 (2)	Milk on menu once a day for children; no tea or coffee (1)	Tea or coffee instead of milk (0)	....	
	Cereals and bread used frequently (1)	Cereals or bread once a day only (½)	Cereal rarely used (0)	....	
	Rice or potatoes used frequently (1)	Rice or potatoes infrequently (½)	Rice or potatoes used rarely (0)	....	
	No rich desserts (1)	Infrequent (½)	Frequent (0)	....	
	Have learned to omit foods I do not digest (1)	Have learned a few foods I cannot digest (½)	Have learned them but continue to eat them (0)	....	
	Laxative foods once a day (1)	Laxative foods infrequently (½)	Laxative foods not considered (0)	....	....
GRAND TOTAL					

REFERENCE BOOKS

Broadhurst, *Home and Community Hygiene*, Chapter III (Teacher's use). J. B. Lippincott Company.

Bulletin 13, American School of Home Economics, Chicago.

Human Nutrition, Bulletins 6 and 7. Cornell Reading Course.

Davison, *The Human Body and Health*. American Book Company.

Fisher and Fisk, *How to Live*, Chapter II. Funk and Wagnalls.

Hunter, *A Civic Biology*, Chapters XIX, XX. American Book Company.

Hunter, *Laboratory Problems in Civic Biology* (For teachers). American Book Company.

Lusk, *Food in War Time*. W. B. Saunders Company.

Ritchie, *Physiology and Sanitation*, Chapters VII, VIII, IX. World Book Company.

Rose, *Feeding the Family*. The Macmillan Company.

Stiles, *Nutritional Physiology* (For teachers). W. B. Saunders Company.

Stiles, *Human Physiology*, Chapters XXV, XXVI. W. B. Saunders Company.

CHAPTER VII

PURE FOOD IN THE HOME

Problems. — 1. *To learn what causes food to spoil.*

2. *To find out how yeast assists in bread making.*

3. *To discover methods of keeping foods for long periods of time.*

4. *Why is there a difference in the efficiency of different refrigerators?*

5. *To discover the most favorable conditions for the growth of bacteria.*

Experiments. — 1. How and why yeast is used in bread making.

2. What conditions are favorable and what unfavorable for the growth of bacteria?

3. What effects have different preservatives upon bacteria?

Project I. — TESTING AND PRESERVING EGGS FOR HOME USE.

1. TESTING. Devise means for testing quality of eggs. (Candling; 10% brine solution.) Make test of fresh, stale, and good storage eggs. (See United States Department Agriculture, Farmers' Bulletin No. 471, and Sherman's Food Products, page 144.)

2. PRESERVING. Methods in use? Principle of preservation? Why must fresh, clean, and unwashed eggs be used when preserving in water glass?

3. COST OF EGG SUPPLY. Prices paid for eggs at different seasons? How many eggs in a year? What saving would be made by preserving three fourths of this supply?

Project II. — To pasteurize your home milk supply.

If your milk is purchased is there any evidence to indicate whether or not it has been pasteurized? What is the evidence? Reasons why you prefer pasteurized milk? Devise apparatus for pasteurization. What temperature will you use? Give in your report a full account of new facts learned, diagram of apparatus, and results secured.

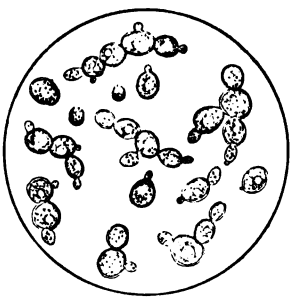
Thought Question.

In a test, 50 pounds of ice were put into the refrigerator on a warm, muggy day. The refrigerator was opened when necessary to put in and to take out food. All the drip water going from the refrigerator was saved and weighed. It weighed more than 50 pounds. Explain why.

Why foods spoil. — We are well aware that foods do not keep indefinitely. Peaches, pears, and apples rot; eggs, meat, and fish spoil; and milk and cooked cereals become sour. Why does this happen? We know that if foods are placed in the ice box they will not spoil so soon. We know that if we boil certain kinds of foods they are less likely to spoil, and we are all familiar with the use of canning as a means of keeping foods; but why do foods become unfit for use eventually? Take small quantities of several different kinds of foods, for example, milk, a piece of meat, potatoes, and cooked cereal, divide each food into two equal portions, and place in separate dishes or jars; seal tight. Place these jars in a large dish of water and boil them for one hour. After this boiling we are sure that everything that might have been living in the jars is dead. If we now open one jar of each food, keeping the other closed, and examine their contents after four or five days, we shall find that in the open jars, the food has begun to spoil, while in the closed jars, it is still good. Comparing this with our previous experiments with the air, we may conclude that whatever causes the food to spoil must come

from the air which is in contact with the food. As a matter of fact this is true. The tiny plants of the home — yeasts, molds, and bacteria — are always present in the air, although we cannot see them, and when they lodge on food and grow, they cause certain changes to take place in the food. These changes cause the food to have an unpleasant taste and odor. In fact, its quality is so changed that it is no longer suitable to eat.

Yeasts and what they do. — All boys and girls who live in the country know that apple juice or grape juice, if allowed to stand exposed to the air, will very soon ferment, that is, little bubbles will appear in the liquid, and a prickly, pungent taste is noticeable. The yeast changes the sugars in the fluid to alcohol and carbon dioxide is formed. The escaping bubbles of this gas may be seen as the liquid ferments. Yeasts are tiny plants made up of a single cell or unit of building material. They grow very rapidly under favorable conditions. These conditions can be easily shown by a home experiment.[1] Yeasts are useful in commercial industries which make use of fermentation. They are of great value also in the home in causing bread to rise.



Yeast plant.

Experiment. — How and why yeast is used in bread making.

Materials: Flour. Water. Sugar. Salt. Lard. Yeast cake. Baking tins.

Method: Make a dough by mixing the flour, sugar, salt, lard, and water

[1] See Hunter's *Civic Biology*, page 137.

to form a thick paste. Add a little yeast which has been mixed with lukewarm water. Divide this into three parts. Keep the first of these at a temperature of 85 to 90 degrees, the second in a cold temperature, and the third at the room temperature, say about 70 degrees, for several hours. Then bake the three samples.

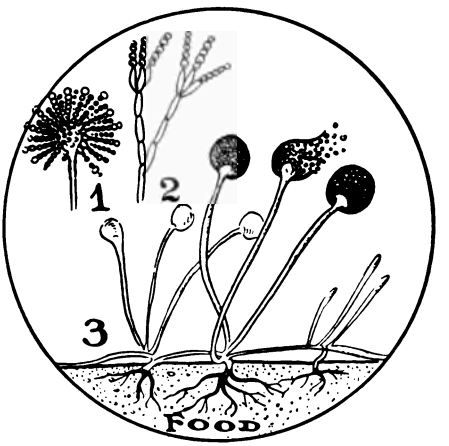
Observation: Compare the three lots for appearance, texture, and taste.

Conclusion: How do you account for the pores in the bread? What caused the bread to rise? Under what conditions does the rising take place best?

Bread making. — Most of us are familiar with the process of bread making. The materials used are flour, milk or water or both, salt, some butter or lard, a little sugar and yeast. The sugar hastens the process of fermentation, or "*rising*," as it is called. After mixing the materials thoroughly, the dough is put in a warm place (about 75° Fahrenheit) to "rise." If we examine the dough after some hours, we find it filled with holes, which give the mass a spongy appearance. The yeast plants, owing to favorable conditions, have grown rapidly and made the cavities with carbon dioxide. Alcohol is present, too, but this is evaporated when the dough is baked. The baking cooks the starch of the bread, drives off both the carbon dioxide and alcohol, and kills the yeast plants, besides forming a crust on the loaf.

Molds in the home. — One of the most common enemies of food in the home is mold. If you place two pieces of bread, one kept moist, and the other dry, side by side in the kitchen or living room, the dry bread will remain unchanged and a fuzzy growth will soon appear on the moist bread. This fuzzy growth later turns black. This growth is composed of a large number of little mold plants (see figure) which take root on the surface of the bread, obtain their food from it, grow in time so as to cover it, and produce

little upright *fruiting bodies*. These fruiting bodies bear tiny little seedlike structures, called *spores*, which are blown around in the air, and grow under favorable conditions. What are these conditions? Refer to your two pieces of bread. Warmth and moisture are necessary for the growth of all tiny organisms. Molds do considerable damage, although they do not render foods completely unfit to eat. You all remember scraping the layer of mold from cheese, before using it. As a matter of fact, certain cheeses get their flavor from the molds that grow in them. Molds also attack other organic materials besides foods. They grow on shoes, leather, paper, or even moist wood. At least one troublesome skin disease, called ring worm, is due to the growth of molds in the skin.



Three different types of mold plant. Notice the fruiting bodies, containing spores. 1. Cheese mold. 2. Corn smut. 3. Bread mold.

Conditions favorable for the growth of bacteria. — By far the most important enemies of pure foods are bacteria, which cause food to decay. We can show the factors which influence the growth of bacteria by the following experiment:

Experiment. — What conditions are favorable and what unfavorable to the growth of bacteria?

Materials: Beans. Test tubes.

Method: Soak half of the beans in water overnight. Crush them and place a portion in each of three different test tubes. Add a few drops of water to each test tube. Place one of these test tubes where it will be kept warm, about 90 degrees. Place another in the refrigerator, close the third with a wad of cotton and heat to the boiling point. Crush one or two of the dried beans and put them in a test tube in a warm place. Compare the odor in these tubes in three days.

Conclusion: In which ones is decay taking place? Is this due to action of bacteria? Why do you think so? Name at least two conditions which favor bacterial growth and two conditions which are unfavorable to it.

The experiments show us that bacteria need moist food and a warm temperature in order to grow well. Grains, crackers, dried fish, and dried fruits all are examples of foods which keep well because they contain very little water. Boiling or sterilizing kills bacteria. It can be shown that they need air, and that light is unfavorable for their rapid growth. Sunlight is known to be one of the best germ killers we have. For that reason sunlight is important in both sleeping and living rooms.

Foods most easily spoiled by bacteria. — If you were to select a large number of different foods and test them to determine in which bacteria grow most rapidly, you would find that the foods containing moisture, and a large amount of protein, are most favorable for bacterial growth. As the bacteria feed on this protein, it falls to pieces and eventually rots. It is broken down by the action of bacteria into gases, liquids, and some solids. It has a characteristic "rotten" odor, and poisons which come as a result of the work of the bacteria. Some of the poisons are called *ptomaines*. No food should be eaten that smells badly or appears to be decayed. The use of common household preservatives in checking bacterial action may be seen from this experiment.

Experiment. — What effect have different preservatives upon bacteria?

Materials: Beans. Test tubes. Salt. Sugar. Vinegar. Boric acid.

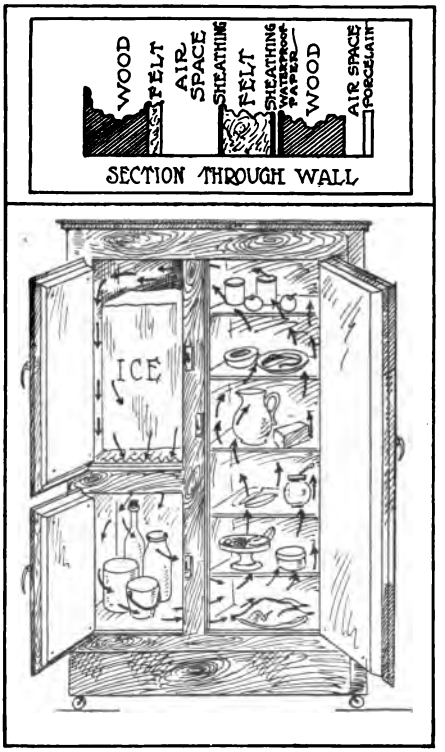
Method: Soak beans in water overnight and crush them. Put a portion into each of seven test tubes. Add water to cover. Set one tube aside; add preservatives as follows: No. 1, untreated; No. 2, one fourth teaspoonful of salt; No. 3, one fourth teaspoonful of sugar; No. 4, one teaspoonful of sugar; No. 5, one fourth teaspoonful of vinegar; No. 6, one teaspoonful of vinegar; No. 7, a pinch of boric acid. Leave these tubes open in a warm room. A bad odor will result from bacterial growth. Test for odors every two days for two weeks. Make tabulated form for recording the result of the test.

Preservatives and their use. — Foods are often protected against bacteria by adding substances in which bacteria cannot live and develop. Such materials as salt, sugar, vinegar, and some spices are harmless preservatives. In recent years, other substances, such as benzoate of soda, borax, or boracic acid have come to be used as preservatives, but the latter materials are harmful, especially when used in large quantities.

Cold storage meat warehouse.

How may we keep germs from spoiling foods? — From the experiments that we have performed, we find that intense heat and intense cold prevent the growth of germs. Bacteria are prevented from growing in foods

while kept in cold storage from six months to two years or more. But we must remember that intense cold, while it prevents the growth of bacteria, does not kill them, and cold storage foods, if placed in favorable conditions for the growth of germs, will soon spoil. On the other hand, heat if continued long enough kills bacteria; and no germs will grow in foods thus heated provided they are kept from air which contains germs. With a knowledge of these facts we can better understand the principles underlying the use of the ice box, cold storage, and canning.



Circulation of air in the refrigerator. What foods are placed below the ice chamber? Why?

Value of the refrigerator in the home. — We have seen that warm, moist air helps germs to grow, and decay to take place. The refrigerator prevents this decay by surrounding foods with dry, cold air. Left-overs which otherwise would be wasted are thus saved for use, and foods and drinks are made more palatable.

Construction of the refrigerator. — The household refrigerator is really a large box with thick, heat-insulating walls, and with doors or covers to the several compartments inside. There is always one chamber for the ice, and several others with shelves for food. All of the compartments within are connected by air ducts or spaces, so that there is a free circulation of air throughout the entire refrigerator. The drainage pipe leads to a pan, or to a waste pipe. This drainage pipe is protected by a trap which prevents warm air from coming in. The wall is of much importance; one of the best is made of layers suggested in the diagram. If heat enters this wall, it must go through all of these insulating substances.

How to use the ice box. — When air comes in contact with ice, it gives up heat to the ice, and becomes colder and heavier, and sinks to the bottom of the ice chamber. An outlet below the ice allows this cold air to pass out at one side to the bottom part of the refrigerator, where warm food substances give off their heat to the cold air, which is warmed and gradually rises, passing in again at the top of the ice chamber. Thus we have a circulation of air within the ice box.

The warm air, returning to the ice, causes some of it to melt, and the heat is thus carried off in the water which drips out into a drain outside. Since most foods have more or less odor, we must place those which give off the most odor at the top of the ice chest where the air is warmer, while meats, milk, and butter should be placed in the coldest part of the ice box, where they will not take the odor from other things. If you want your ice box to be cold inside, do not cover the ice with newspapers or a woolen

The iceless refrigerator. The outside canvas dips into a pan of water at the top and drains into another pan at the bottom of the refrigerator. (U. S. Dept. Agri.)

blanket. If you desire to keep the ice, and not the food, then this is the way to do it.

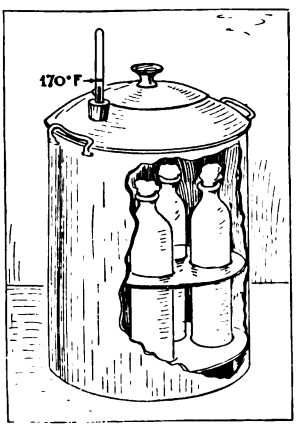
The iceless refrigerator. — An interesting home project is the making of an iceless refrigerator. Directions may be found in the U. S. Dept. of Agriculture pamphlet, Food Thrift Series, No. 4. The principle of evaporation and transfer of heat from the inside to the outside of the box explains its value. Study the diagram and see how it might be usefully applied to your own home.

Thermos bottle. — The thermos bottle, as a study of the diagram will show, is another application of insulation. It is essentially a double walled bottle or one bottle inside of another, with a vacuum space between. A vacuum is a better insulator than air. The inside walls of the bottles surrounding the vacuum are mirrors. They reflect radiant heat energy and prevent its passage across the vacuum. Thus the thermos bottle keeps cold substances cold, and hot substances hot, by means of insulation.

Canning foods. — Canning is simply a method by which foods are boiled to kill the bacteria in them and then placed in vessels into which no more bacteria

can gain entrance. This is done usually by boiling fruits or vegetables, sometimes with sugar or salt, and placing them immediately in sterile jars and then sealing them tightly. They may also be canned by simply placing food uncooked but clean in cans, closing the cans, and then sterilizing by boiling for a considerable period of time. The United States Government, Department of Agriculture, Farmers' Bulletin No. 839 gives full directions for canning by this last method, called the cold-pack process. Some vegetables such as peas, beans, and corn are very difficult to can, probably because of spores of bacteria which are attached to them, and it requires a longer heating to kill the spores. Fruits, on the other hand, are usually much easier to sterilize. The main thing to bear in mind is to have the jars as well as the material that goes into them, sterilized, that is, absolutely free from all living matter. This can be done best by long boiling.

Section of thermos bottle. (After Hoadley.)



Pasteurizing apparatus, an arrangement by which milk is conveniently heated to destroy disease germs. The thermometer tells the degree of heat used.

Pasteurization of milk. — Milk is one of the favorite foods of bacteria. It is also a very important food for children, and since a baby's digestive system is easily upset, we should pro-

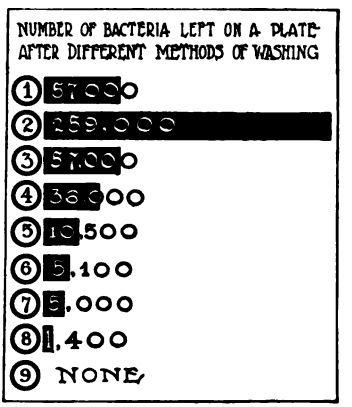
tect it by having the milk as free from germs as possible. All milk contains some germs, even shortly after taken from the cow, the most numerous being those which cause milk to sour. To kill the harmful bacteria and not injure the milk, a method known as *pasteurization* is used. This pro-

A model kitchen.

cess is named after the great French scientist, Louis Pasteur, who did so much to apply his knowledge of harmful germs to human betterment. By this method milk is heated to a temperature of not over 150 degrees Fahrenheit for a period of ten minutes to one half hour. The diagram at the bottom of page 125 shows an excellent home pasteurization apparatus. In cities most milk delivered to the home has been pasteurized, because the milk is sometimes forty-eight hours old before it is delivered to customers.

Flavors in foods. — Foods frequently get a large part of their flavor from the bacteria which live in them. The flavor of butter, the "gamey" taste of certain meats, the flavor of sauerkraut, are due to the work of bacteria. Bacteria have some useful, as well as harmful, effects in foods.

A clean kitchen necessary. — Since foods are handled in the kitchen, it goes without saying that a clean kitchen will go a long way to prevent spoiling of foods. This means that all surfaces in the kitchen should be washed frequently. Why? Tables and shelves should be covered with oil cloth or something which can be wiped off and dried quickly. Wooden surfaces, especially when they become greasy, make excellent homes for bacteria. Remember that hands must be kept clean when handling foods. Since flies carry disease the kitchen should be screened. Dishes should be washed clean with plenty of soap and hot water. The accompanying diagram will illustrate how the clean washing of dishes helps in keeping bacteria from foods.



1. As plate leaves table. 2. Washed in lukewarm water; not rinsed. 3. Rinsed in lukewarm water after washing. 4. Warm water; not rinsed. 5. Rinsed in warm water after washing. 6. Warm water; rinsed in hot. 7. Washed in hot water; not rinsed. 8. Washed and rinsed in hot water. 9. Washed and rinsed in boiling water.

An excellent method of drying is to stack the dishes on the draining board and then to pour boiling water over them. Why is this better than drying them with a hand towel? Is it a good plan to leave the dishes to drain overnight? Why not?

Hints on the use of this score card. — We are all interested in keeping well and strong. We all like good things to eat, too. Study the conditions in your home, suggested by each item in the score card. Be fair in your marking. The purpose is not to see who can get the highest score but to show each one of you just what conditions surround you and to suggest those things which need correction the most.

SCORE CARD. PURE FOOD IN MY HOME

	Excellent	Fair	Very Poor	My Score	
					Total
Cleanliness in the care of food	Closed closet for dishes — Glass doors (2)	Closed closet; wooden doors (1)	No closet for dishes (0)	....	
	Dishes scalded, drained dry (2)	Dishes dried with clean towel (1)	Dishes not scalded (0)	....	
	Wash hands with soap and water before handling food (3)	Sometimes remember to wash hands (1)	Never wash hands before handling food (0)	....	
	Kitchen table, floor, woodwork, and walls always kept clean (3)	Table, woodwork, floor, and walls usually clean (1)	Kitchen table, woodwork, floor, and walls seldom clean (0)	....	
Refrigerator	Large enough to hold all food (2)	Too small (1)	No refrigerator (0)	....	
	Enamel or porcelain lining, easily cleaned (2)	Galvanized iron or zinc interior (1)	Rough or cracked interior (0)	....	
	Economical of ice, good circulation (2)	Wasteful of ice (1)	Does not keep ice or food; poor insulation (0)	....	
	Food properly placed to show knowledge of convection currents (2)	Food in part properly placed. Some foods spoil or taste (1)	No knowledge of convection currents shown (0)	....	
	Washed thoroughly twice a week (2)	Washed thoroughly once a week (1)	Washed irregularly Has odor (0)	....	....
Sterilization and pasteurization	Left-overs heated to boiling point to prevent spoiling (3)	Some left-overs thrown away because of not being sterilized (1)	No left-overs saved (0)	....	
	No fruits left to spoil (2)	Fruit occasionally spoils (1)	Fruit often spoils, not cooked and saved (0)	....	
	All milk left over scalded for cooking (2)	Some milk scalded, some sours and is thrown out (1)	No milk saved (0)	....	
	Milk for children pasteurized at home or certified milk used (3)	No certified milk but town or city supply pasteurized (2)	No pasteurized or certified milk (0)	....	....

SCORE CARD. PURE FOOD IN MY HOME — *Continued*

	Excellent	Fair	Very Poor	My Score	Total
Use of Preservatives	Proper knowledge of use of preservatives shown. No food wasted (2)	Some food wasted because of lack of knowledge (1)	Much food wasted (0)	....	
	Salt or waterglass used in preserving foods (2)	Salt or waterglass sometimes used in preserving food (1)	Salted food not used; Eggs not preserved (0)	....	
	All extra supplies of vegetables and fruits canned (2)	Part of extra supply canned (1)	None of extra supply canned (0)	....	
	Sugar used in preserving fruits (2)	Some fruits and jellies made, but not all utilized (1)	No homemade jellies or preserves (0)	....	
	No harmful preservatives in bought foods (2)	Use of preservatives in some bought food shown by label (1)	Preservatives other than salt, sugar, and vinegar in much food purchased (0)	....	....
Protection of Foods	Perishable foods kept cool (2)	Perishable foods sometimes kept cool (1)	Much perishable food wasted because not kept cool (0)	....	
	Foods kept covered (2)	Foods sometimes covered (1)	Foods often uncovered (0)	....	
	Canned goods never left in cans after they are opened (2)	Canned goods sometimes left in cans (1)	Canned goods often left in cans after opening (0)	....	
	All foods protected from insect (2)	Insects sometimes get in foods (1)	Insects often in food (0)	....	
	Fly screens in windows; no flies in house (2)	Fly screens in windows; a few flies in house (1)	No screens; many flies in house (0)	....	....
Grand Total					

REFERENCE BOOKS

Allen, *Civics and Health*, Chapter XXV (For teachers). Ginn and Company.

Broadhurst, *Home and Community Hygiene*, Chapters I, III, IV (Teacher's use). J. B. Lippincott Co.

Caldwell and Eikenberry, *Elements of General Science*, Chapter VIII. Ginn and Company.

Clark, *An Introduction to Science*, Chapters IX, XIV. American Book Company

Conn, *Bacteria, Yeasts and Molds of the Home*. Ginn and Company.

Claycomb. *Petri Dish Projects*. School Science and Mathematics, April, 1918.

The Persistent Delusion of Ptomaine Poisoning. Current Opinion, April, 1918.

Hunter, *A Civic Biology*, Chapters XI, XXIV. American Book Company.

Hunter, *Laboratory Problems in Civic Biology*, Chapter XI (For suggested experimental work). American Book Company.

McNutt, *The Modern Milk Problem* (For teachers). The Macmillan Company.

Official Handbook, Boy Scouts of America (Questions on decay). Doubleday, Page and Company.

Public Health Service Bulletin 56, *Milk and its Relation to Public Health.*

Ritchie, *Primer of Sanitation*, Chapter XXX. World Book Company.

Milk, U. S. Department of Labor, Bulletin 35 — Children's Bureau.

Van Buskirk and Smith, *The Science of Everyday Life*, Project X. Houghton Mifflin Company.

Vulte and Vanderbilt, *Food Industries*, Chapter VIII. Chemical Publishing Company.

Weed, *Chemistry in the Home*, Chapter XXIV. American Book Company.

Wing, *Milk and Its Products* (For teachers). The Macmillan Company.

CHAPTER VIII

HOUSEHOLD PESTS AND HOW TO FIGHT THEM

Problems. — 1. *To understand what harm is done by household pests.*

2. *To learn the life history of some harmful insects.*

3. *To find how household pests can be exterminated.*

Experiment. — To work out the life cycle of the fly.

Project I. — TO EXTERMINATE FLIES FROM MY HOME.

1. Find details of various methods of getting rid of flies. Traps, tanglefoot, poison papers, liquids, and powders.

2. Find details of means of preventing production of flies which will be of value in your particular place. Care of breeding places.

3. Make a plan of campaign and carry it out.

4. Make a complete report of your project. State to what extent the fly nuisance has been abated.

Suggested Projects.

1. TO RID THE HOUSE OF RATS AND MICE.

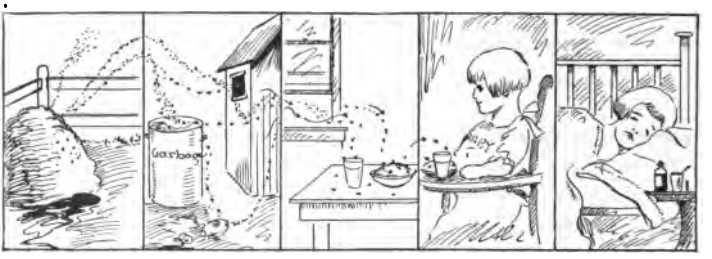
2. TO WORK OUT METHODS OF FIGHTING OTHER HOUSEHOLD PESTS.

3. TO PREPARE PROPER CONTAINERS, AND STORAGE SPACE FOR CLOTHES, AND TO KEEP WINTER CLOTHING OVER SUMMER SAFE FROM MOTHS.

What household pests do. — What a pleasant place the world would be to live in if it were not for the flies and mosquitoes which annoy us, fleas and bedbugs which bite us,

weevils and roaches to get into our foods, and rats and mice to destroy our homes and damage our plants and crops.

Estimates made by the United States Department of Agriculture show that over a billion dollars' worth of damage is done each year to crops and other property in this country by insects alone. An estimate is made that at least a million dollars' damage a year is done by rats in the city of Pittsburgh alone. But aside from these losses the untold suffering and the many unnecessary deaths caused by diseases which are carried by insects and other

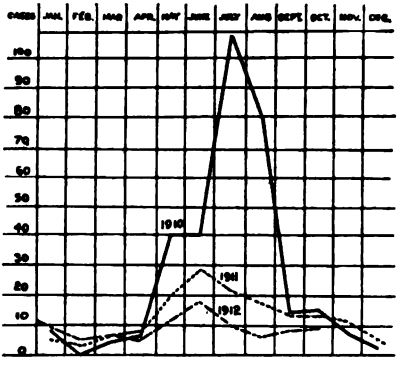


Follow the fly. What happens?

animals, should cause us to spend thought and time in making homes as free as possible from these household pests. Almost every day scientists discover some new relation between insects and diseases. Many infectious diseases depend in part, at least, upon insects as carriers. The fly which to-day puts its dirty feet in baby's cup of milk yesterday lived in a manure heap, and on the way here may have stopped in a privy. This is not nice to think about, but it is fact, nevertheless, and every thinking boy and girl should realize these things.

The house fly in relation to our home. — It is estimated that while snakes kill perhaps two or three people every year in the United States, house flies are responsible for

the deaths of about 100,000 people. This is due to the filthy habits of flies. Probably most of the dysentery and summer complaint, especially of babies, is due directly to flies, for they carry directly to baby's milk on their legs or bodies germs which they have taken from some other sick baby or person having the disease.



There were 329 cases of typhoid in Jacksonville, Florida, in 1910; 158 in 1911; and 87 in the first 10 months of 1912. During the winter of 1910–1911, 80 to 85 % of the outdoor toilets were made flyproof. How would you account for the great decrease in cases of typhoid indicated in 1911 and 1912?

Typhoid fever, a well-known disease, responsible for a great many deaths, especially in country districts, is undoubtedly largely spread by means of flies. A study of the accompanying diagram will show clearly that the warm weather, spread of typhoid, and diarrhœa are coincident with fly time. A knowledge of the life history of the fly will help us to combat the pest.

Experiment. — To work out the life history of the fly.

Materials: A small wire cage. A piece of stale meat.

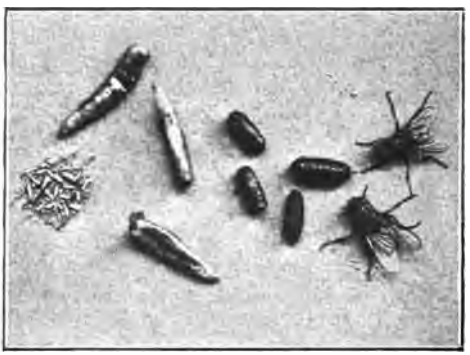
Method: Leave the meat out in the open where there are plenty of flies until you can see fly eggs, then cover it with a wire cage and keep it in a warm place.

Observation: Look at it every few days. What different stages follow the egg stage? How long does it take each stage to develop? Do you think temperature would have any effect on the rapidity of development?

Conclusion: What is the life cycle of the fly?

Application: Does this experiment suggest any method of control of the number of flies about the house?

How to get rid of flies. — In order to rid our houses of these pests it is necessary to know something about the habits of flies. Flies commonly breed in manure, but sometimes in garbage which has been allowed to stand in uncovered cans and in rotting masses of paper and other rubbish, provided it is moist. A fly does not take more than ten days to complete its life history in warm weather. The eggs hatch in about eight hours into maggots. These whitish wormlike animals burrow into the manure pile and there after six or seven days become brown pupae, and hatch out three days later as adult flies. Since an adult fly lays about one hundred and fifty eggs at a time, and about one half of all flies are females, it is not difficult to estimate how many flies might come from one pair in a season. Hodge has estimated that within three months the offspring from one fly would amount to 143,675 bushels of flies. If these figures are correct, it is evident that "swatting the fly" or using screens will not do much good unless the flies are "swatted" early in the season when there are not very many which have lived through the winter. Evidently the best things to do are to destroy the breeding places of flies and to trap as many as possible. All manure heaps should be worked over and scattered at least once



Life history of house flies, showing from left to right the eggs, larvae, pupae, and adult flies. (Photograph about natural size, by Overton.)

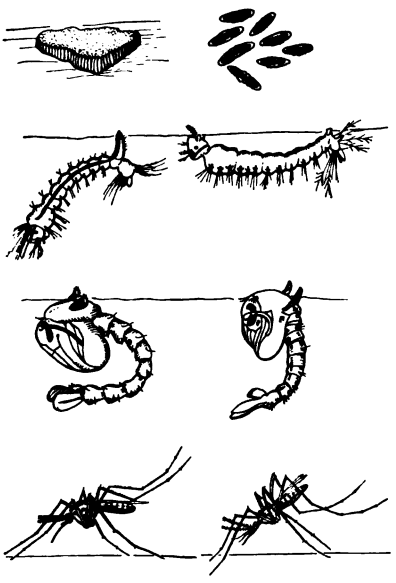
every ten days so that the flies cannot have a chance to breed. Garbage and any material that might form a breeding place should be carefully removed within the ten-day period. One of the best baits for flies is made by adding to a pint of milk and water two tablespoonfuls of formaldehyde. Place a piece of bread in a shallow dish and almost cover it with the poisonous dose. An excellent home project would be the manufacture of an efficient fly trap. The United States Government bulletins, for example, Farmers' Bulletin No. 927, or Hodge's *Nature Study and Life* give descriptions of excellent traps.

A fly trap.

In addition to the house fly, many other flies, as the stable fly, the fruit fly, and the black fly, cause us great annoyance, and some are believed to carry disease.

Mosquitoes. — We have all at one time or another been annoyed by mosquitoes. They render some parts of cities and towns unfit for human residence, not only because of their bite, but because they carry malaria. The old belief that malaria was caused by bad air has long been exploded, for experiments have proved that a certain kind of mosquito, the *anopheles*, is responsible for carrying this disease. A careful study of the diagram will show how we can distinguish between the harmless *culex* and the harmful anopheles. The harmful one, as you notice, stands with its body oblique while the culex holds

its body parallel to the surface. Mosquitoes breed in water, and unfortunately for us, rain barrels, roof gutters, or any place where water remains for two weeks or more can raise a large number of these nuisances. Their life history can be understood by studying the diagram below. The common culex, the house mosquito, lays from two hundred to four hundred eggs. The little wigglers which come from the eggs live in water, obtaining their oxygen through a long tube which sticks out of the water when they go to the surface to breathe. It takes from two to three weeks for the mosquito to complete its life from the egg to the adult. Since mosquitoes live during this time under water, and since they must come to the surface to get air, a simple way to destroy them by preventing their breathing is to pour oil over the standing water in which they lay their eggs. Sometimes it is necessary to drain swampy areas where standing water makes breeding places, and many households have been relieved from the plague of mosquitoes by the simple removal of empty cans or barrels which might hold water. Why not make a survey of



The four stages in the life history. Read from top to bottom as follows: egg, larvae (wigglers), pupae, adult. At the left is seen the *culex;* at the right, the harmful *anopheles*.

your own house and grounds and make sure that no standing water is near, for mosquitoes rarely fly more than a few hundred yards from where they hatch. The introduction of goldfish, sticklebacks, or other small fish will soon rid ponds of mosquitoes.

Yellow fever, which at one time was a terrible menace in this country, is carried by another kind of mosquito. We will discuss this more fully in "Civic Science in the Community."

Fleas. — The ordinary dog and cat flea should always be considered a menace to health, for it may carry bubonic plague and infect people with it. Plague is a disease of rats, but is spread by fleas which live upon them. Fortunately this disease is not prevalent in this country, although in some parts of the world, particularly in China, it is killing many thousands of people yearly. Fleas flourish in dust, under carpets, in cracks, and particularly where dogs and cats sleep. Mats on which these animals sleep should be constantly dusted and cleaned, and benzene or pyrethrum powder may be used to fight the pests.

Flea which transmits bubonic plague from rat to man.

The "cootie."

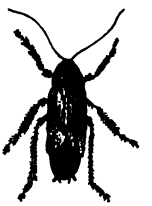
Lice. — Lice are wingless insects which have come into prominence during the World War. The body louse is the "cootie" of the soldier. It becomes a very serious pest to those obliged to live in dirty surroundings, and can be eradicated only by having the clothes sterilized and by treatment of the body with ointments. The head louse sometimes found in the heads of school children is very annoying and hard to get rid of. The "nits" or eggs are

attached to hairs, and can only be removed after thoroughly washing and combing. The application of larkspur is found to kill the pests.

Bedbugs. — Although the bedbug is usually found in dirty homes, it may come from outside into clean houses. Bedbugs move around only at night, and their very flat bodies get into small crevices, especially along wall boards and in wooden beds, where they may become very annoying. They are much more active in hot weather than in cold. While the bite is not serious, it is believed sometimes to carry diseases. To rid the house of bedbugs it is necessary to clean all furniture and woodwork thoroughly. Every crack in the furniture and floors should be treated with formalin or an insecticide made particularly for destroying this pest.

The bedbug.

Insects which attack food. — Some household pests are attracted to the house by our food. Cockroaches are found usually around sinks or in food closets. They eat almost anything, and are apt to be a great nuisance, although the damage they do is not very great. They are difficult to get rid of, as every housewife knows. They may be poisoned by feeding them a mixture of sugar and powdered borax. All cracks and crevices where they hide should be sprayed with bisulphide of carbon which will kill them. They may be trapped by placing food in a deep dish into which they may crawl by means of sticks, but from which they cannot get out.

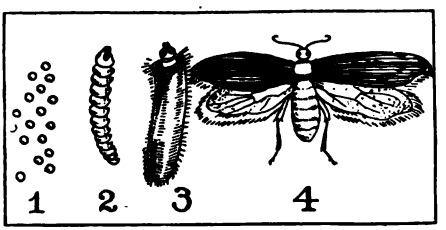

The cockroach.

Ants also are very troublesome, as they destroy many kinds of foods. The best way to rid the house of them is

to find their nest and pour into it a few ounces of carbon bisulphide. (This is a dangerous liquid to handle, but is less explosive than gasoline.) Colonies of ants in the house may be treated also with gasoline or boiling water, and the ants may be kept from getting into the house by placing a border of some substance that they do not like, such as powdered borax, on the threshold. Sulphonaphthol is another efficient means of ridding the house of ants.

The ant.

Insects which attack clothes. — Two insects, clothes moths and carpet beetles (Buffalo moth or Buffalo bug), are pests which do much damage to stored materials, especially our clothes and rugs. The young, or larvae, feed on the woolen and fur of the clothes, and do much damage in this way. If these materials are well dusted and allowed to hang outside in the sun a few hours before putting them away for the summer, and then packed into tight boxes or bags, they will not be troubled by moths. Moth balls and camphor keep out the insects, but do not kill them, so that if clothes are put away with the insect in them they will not be protected. The carpet beetle can be fought in the same way as the clothes moth. It feeds on carpets and other goods stored away.



The clothes moth. 1, eggs; 2, larva; 3, pupa; 4, adult.

Household insects may be grouped according to the damage they do. The following experiment is suggested

that you may see which insects should be grouped together:

Experiment. — To classify the insects of the home according to the harm they do.

Make a list of all the household insect pests you can find out about. List these under the suggested headings according to the harm they do. Possibly some one insect will need to be listed in more than one column.

Disease Carriers	Eats and Destroys Foods	Annoys and Bites	Destroys Textiles and Clothing

The house rat. — David Lanz of the Department of Agriculture calls the rat the worst mammalian pest known to man. Not only do they do many million dollars' damage to grain stored in barns but they kill many young chicks and destroy a great number of eggs. They have been estimated to do $200,000,000 damage in the United States every year. Buildings are damaged, water pipes gnawed, and buildings flooded. Many fires are caused by rats gnawing off the insulation of electric wires and by setting off matches which they have taken to their nests. In addition to this, rats are responsible for killing millions of people in India and elsewhere lately by carrying the germs of the bubonic plague, the "Black Death" of the Middle Ages.

One of the practical projects a boy can work out is to lay plans for the trapping of rats or killing them by means of poison. One must remember that poisons are dangerous to handle and that rats and mice are cunning, so that it takes constant and careful work in order to finally rid the

house or barn of these destructive pests. Concrete construction which is rat proof is one of the latest and best

How the house rat does damage. (Photo of group in American Museum of Natural History.)

methods of preventing rats from doing damage in the home. The best proof that this chapter has not been written in vain will be the home work of those who read it. Let us all work together to make our homes safer and better places in which to live.

Use of the score card. — While it is not always pleasant to admit that things are not as they should be, yet that is a good way to begin and improvements are sure to follow. If home conditions show up badly in this card, each boy and girl should go to work at once to make them better. Naturally you need not show the details of this card to any one, although your total score might be given.

SCORE CARD. HOUSEHOLD PESTS

	Excellent	Fair	Very Poor	My Score	Total
FLIES	No manure piles (2)	Manure piles protected (1)	Manure piles never disinfected (0)	....	
	Garbage pail with tight cover (1)	Garbage pails loose covers (½)	Garbage pails no cover (0)	....	
	Garbage pail *scalded* twice a week in hot weather (1)	Garbage pails scalded once a week in hot weather (1)	Garbage pails scalded infrequently (0)	....	
	No outdoor privies (2)	Outdoor privies well screened (1)	Privies not screened (0)	....	
	No decaying refuse in yard (2)	Decaying refuse in yard occasionally (½)	Yards with much refuse (0)	....	
	All windows screened (1)	Kitchen windows screened (½)	No windows screened (0)	....	
	Fly traps or poisons and swatters (1)	Fly traps or poisons or swatters (any two) (½)	No traps or poisons; swatters only used (0)	....	....
MOSQUITOES	No culex (2)	Very few culex (1)	Many culex (0)	....	
	No anopheles (2)	Very few anopheles (1)	Many anopheles (0)	....	
	No breeding places of any kind (4)	Breeding places not near home (2)	Breeding places near home (0)	....	
		All standing water oiled regularly including rain barrels (1)	Standing water not regularly oiled (0)	....	
	No mosquitoes in house (2)	Mosquitoes rare in house (1)	Many mosquitoes in house at night (0)	....	....
BODY PESTS	No fleas on cat or dog in house (3)	Fleas on cat or dog not in rooms. Pets washed frequently (2)	Fleas in carpets or rugs. Children often bitten. Dog or cat not washed (0)	....	
	No bedbugs (3)	Bedbugs infrequently found. Insecticide used frequently (2)	Bedbugs frequent. Insecticide not used (0)	....	
	No head lice (3)	Children rarely have head lice or nits. Treatment given frequently (1)	Children frequently have head lice or nits (0)	....	
	No other body pests (1)	Other body pests sometimes found (½)	Other body pests frequent. Dirty conditions of clothes or body (0)	....	....
FOOD AND CLOTHES PESTS	No cockroaches or water bugs (2)	Roaches or water bugs infrequent. Constant care exercised. Insecticides used (1)	Roaches and water bugs frequent; sink dirty; food left around kitchen; no insecticides used (0)	....	
	No ants (2)	Ants sometimes in pantries; not in foods. Insecticides used (1)	Ants numerous; much food spoiled by them (0)	....	....

SCORE CARD. HOUSEHOLD PESTS — *Continued*

	Excellent	Fair	Very Poor	My Score	Total
Food and Clothes Pests	No weevils or other food-destroying insect (2)	Other insects destructive to foods sometimes found (1)	Much food thrown out because of weevils or other insects. No care taken (0)	....	
	No clothes moths or Buffalo moths. All precautions taken (2)	Clothes moths and Buffalo moths do infrequent damage. Clothes well cleaned and put away with proper care (1)	Clothes moths or Buffalo moths do much damage (0)	....	
	No other insect pests (2)	Other pests sometimes seen (1)	Other pests common (0)	....	....
Rats and Mice	No rats in house or barn (6)	Rats infrequently seen; little damage done (1)	Much damage by rats (0)	....	
	No mice in house or barn (4)	Mice infrequently seen; little damage done (1)	Much damage by mice (0)	....	
		Dog and cat (1)	No dog or cat (0)	....	
		Traps or poisons used (1)	No traps or poisons used (0)	....	
		Concrete construction (2)	No concrete construction or tin to cover holes (0)	....	....
Grand Total					

REFERENCE BOOKS

Broadhurst, *Home and Community Hygiene*, Chapter IX (For teachers). J. B. Lippincott Company.

Caldwell and Eikenberry, *General Science*, Chapter XX. Ginn and Company.

Doane, *Insects and Disease*. Henry Holt and Company.

Headler, *Effective Methods of Fly Control*. Sci. Amer. Supplement, March 9, 1918.

Headler, *The Mosquito Question*. Scientific American Supplement, April 6, 1918.

Herrick, *Insects Injurious to the Household*. The Macmillan Company.

Hodge and Dawson, *Civic Biology*, Chapters X, XI, XIII, XVIII (Good). Ginn and Company.

Hodge, *Nature Study and Life*. Ginn and Company.

Hunter, *A Civic Biology*, Chapter XV. American Book Company.

Hunter, *Laboratory Problems in Civic Biology*, Chapter XV. American Book Company.

Kellogg, *American Insects* (For teachers). Henry Holt and Company.

Kellogg and Doane, *Economic Zoölogy and Entomology*, Chapters XXX, XXXI. Henry Holt and Company.

Ritchie, *Primer of Sanitation*, Chapter XXIX. World Book Company.

Smith and Jewett, *Introduction to the Study of Science*, Chapter XII. The Macmillan Company.

CHAPTER IX

HOW WASTES ARE REMOVED FROM THE HOME

Problems. — 1. *To understand how wastes are removed from the body.*

2. *To understand the system of waste removal needed for the home.*

3. *To learn how the various plumbing fixtures work.*

4. *To see how a septic tank does its work.*

Experiments. — 1. To see how a siphon works.

2. To understand how a flush tank works.

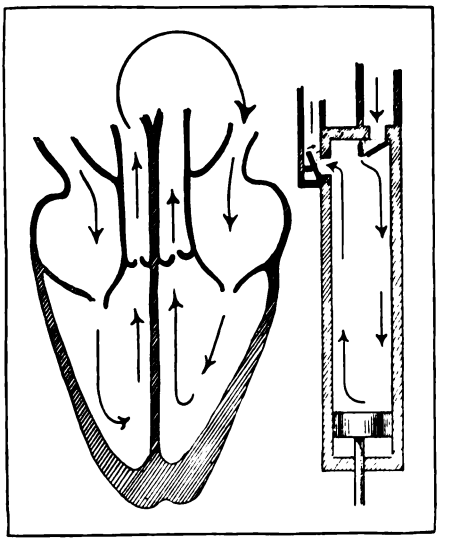
Project I. — To prepare myself to keep the home plumbing system in order.

This involves a thorough study of the devices, piping, etc. in the home. Diagrams should be made of pipe systems showing valves and cut-offs, etc., and of individual devices, as traps, bowls, toilets, flush tank, and faucets.

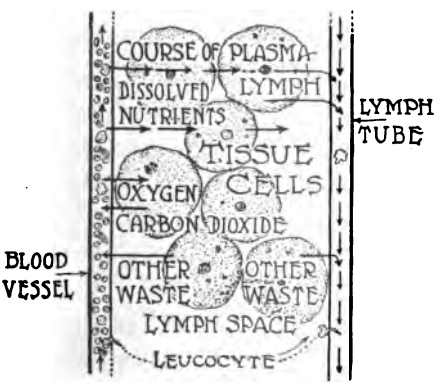
Study the devices seen at plumbers. Talk with men who know how these devices work. Find out how to remedy a clogged sink drain, toilet, and wash bowl drain. Learn what to do when pipes are frozen and when a large leak occurs, and how to repair your faucets. Be sure you know how to shut off water, gas, and electricity from the entire house.

A collection of pictures of plumbing devices cut from magazines and described in your own words will make a splendid section in your final report of this project.

How wastes are removed from the human body. — We have seen that the human body uses foods wherever work is done in it. After the food is digested in the food tube it is absorbed by the blood which carries it through a system of pipes called *veins* to a pumping station called the *heart*. This is a double station; the left side of it forces the blood through the *arteries* (see diagram) to all parts of the body, while the right side pumps blood to the lungs. Here, as we have seen before, it gives up carbon dioxide, and receives its burden of oxygen. Before the blood reaches the cells, the little units of building material of which the body is composed, the vessels containing it divide into tiny tubes called *capillaries*.



The upper cavities in the heart are called auricles (right or left), the lower, the ventricles (right or left). Follow the arrows. In what respect is the heart like a force pump?



The exchange between blood and the cells of the body.

The liquid food soaks through the thin walls of the capillaries and bathes the cells so that they are continually supplied with food. In the cells the food is oxidized and energy is released. Some of the food containing nitrogen is used to build tissue and repair the body. Nitrogen does not unite easily with oxygen, and hence a considerable amount of nitrogenous material must be passed from the body as waste. This nitrogenous waste, along with other waste materials, is passed out from the cells into the lymph spaces, then into the lymph tubes, and ultimately gets into the blood again, this time being carried through *veins*, which are tubes leading toward the heart. Wastes containing nitrogen are finally collected by the kidneys, from which organ they are passed out of the body in the urine. Through the food tube, other wastes and material which cannot be digested are passed out in a partly decayed condition from the body. This work of decay is carried on by means of millions of bacteria which live in the lower part of the food tube.

Why we need a system to remove wastes from the home. — All body wastes from the home as well as garbage, used water, and the like must be removed from our homes and put where they cannot do any harm to others. Wastes from the body contain bacteria, possibly some harmful ones. If we were alone in the world we could afford to be selfish, but when we are living where there are many other people, we cannot do anything which might do harm to others. Open privies to which flies can go might be the means of spreading disease among one's own brothers and sisters. Garbage thrown out and left to decay may mean millions of flies for you and your neighbors. Water and wastes from the kitchen sink allowed to form a dirty, smelling pool outside

may become the breeding place of insects as well as a place of foul odors. The purpose of this chapter is to point out some of the means by which sewage is removed from the home and rendered harmless to others. We must remember that sewage or material containing wastes from the body substances is very dangerous to health. It has been shown many times that as a result of carelessness, germs from sewage pass into the drinking water or get on the food. It is necessary, therefore, that sewage everywhere, in cities as well as the country, be properly disposed of else it becomes a menace to health. In 1854 there was a great outbreak of Asiatic cholera in London. Some parts of the city were stricken much more than others. In those days people got their water from wells, and the Broad Street pump had such a reputation for clean, sparkling water, that people from blocks away went to it for their drinking water. It was found, however, that one of the greatest outbreaks of cholera was among people taking water from this well, so the health authorities investigated the conditions there. Imagine their horror to find the well water separated by only a single layer of old worn-out bricks from a cesspool which received the waste materials from many cholera patients. As cholera is a disease of the intestines or bowels millions of germs were being placed in that well water every day. After the well was closed to the public, the epidemic subsided in that part of the city. This is only one instance among many where germs in the water supply have done untold harm.

The need of sanitary plumbing. — In these days it is hardly necessary for people to have outdoor insanitary privies. If an outdoor privy is necessary, then all parts should be carefully screened to prevent flies from getting

in, and the lids of the seats should be close-fitting. Earth mixed with lime should be used constantly to keep the waste material in the receiving vault covered so that flies cannot get to it. In most homes nowadays it is quite possible to have indoor toilets and pass the waste material along with the kitchen and other wastes into an underground sewer in cities and into cesspools or septic tanks in the country.

A modern bathroom.

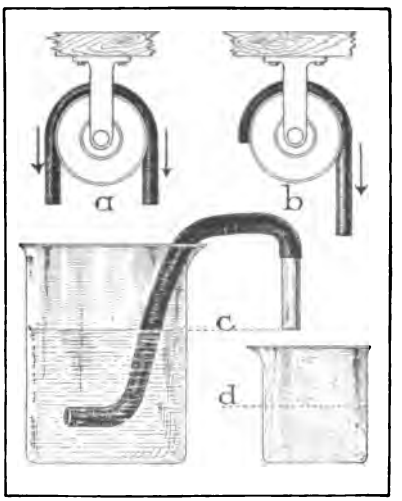
The modern bathroom.—Most houses nowadays have a warm indoor bathroom, furnished with all the fixtures shown in the illustration; a washbasin, bathtub, mirror, cupboard, towel racks, stool, and toilet. Not very many years ago it was thought proper to cover all the plumbing with wood, but this is insanitary, because it makes an excellent place for germs to lodge and grow. Now we find bathrooms furnished with one-piece sanitary bowls, and tubs made either of porcelain or metal, everything raised from the floor, with all parts easy to get at in case of repair. A tub with cold water at least is an essential part of a bathroom, and a shower bath if the water supply is sufficient,

adds much pleasure to the daily life. A little knowledge of a few scientific principles underlying the operation of these fixtures will be useful for us to have and may save much expense and trouble. We have already studied different types of faucets, and know how to make simple repairs on them.

Experiment. — To see how the siphon works.

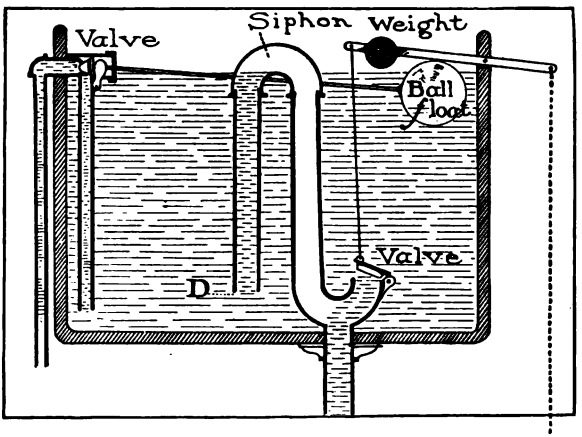
Materials: Battery jar. Glass beaker. Rubber tube. Glass tube. Pulley with little friction. Cord or rope to go over the pulley.

Method: (A) Hang a short heavy cord or small rope over the easily running pulley with the two ends at the same level. See figure (*a*). Result? Change the cord so that one end hangs 6 inches or more lower than the other side. See figure (*b*). Result? (B) Connect a six-inch length of glass tubing to one end of the rubber tube. Fill the entire glass and rubber tube with water. Hold the finger over the end of the glass and put the end of the rubber tube into a jar of water. Hold the end of the glass tube just below the level of the water in the jar, and open it. Carefully raise the tube until the end is just level with the water surface in the jar. See figure (*c*). Does water run out? Does it run back? Give reason. Lower the end of the glass tube so that it is several inches below the level of the water in the jar to (*d*) in figure. Result? Explain. What will happen if it is raised above the level of water in the jar? Try it.



Conclusion: The tube is used in this experiment as a siphon. Explain how much of the action of the siphon depends on the pressure of the atmosphere. How does the analogy with the rope help to explain a part of the action of the siphon?

A flush tank. — If you will examine the diagram accompanying this paragraph carefully, you will find that water gets into the tank through the action of the ball float, which, when the toilet is flushed, opens a valve and allows a new supply of water to come into the tank. When the water reaches a certain level the float automatically closes the valve. The toilet itself is flushed by pulling a lever



The bathroom flush tank.

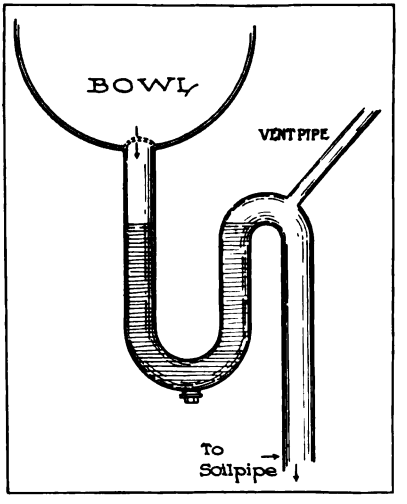
which opens the valve at the base of the siphon. As the water begins to flow this valve closes, and the water in the pipe leading to the toilet acts as the plunger of a piston (see diagram), and water is passed into the flush pipe through the siphon. As soon as the water in the tank is lowered to the point D the siphon tube fills with air and the action stops. The tank then fills up as has been shown previously.

The study of your own home flush tank makes an interesting experiment.

Experiment. — To understand how the flush tank works.

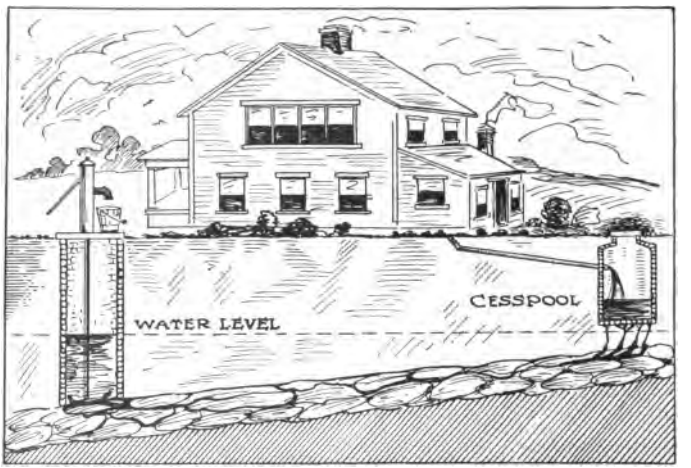
Remove the cover from the flush tank. (A) Pull the lever to allow the water to run out. Locate the inlet valve. Where is it? What controls it? Make a diagram to show clearly how the water inlet is controlled. (B) Hold the ball-float valve to prevent more water entering the tank. Pull the lever to empty the tank. Notice whether the tank is emptied by use of a siphon or whether there is a rubber ball valve. If it has a ball valve, fill with water again and empty. Observe just when the ball closes the valve. Can you explain why the valve stays open just so long? Make one or more diagrams to show the emptying mechanism. How would you make repairs if the rubber valve leaked? What would you do if the ball float were broken off?

The home system of drain pipes. — In order to get water and wastes out of the house it is necessary to have a system of drain pipes consisting of a large *soil pipe* from cellar to roof. All the sinks, toilets, and tubs must connect with this soil pipe. It is necessary, then, to arrange our house so as to have all of the fixtures grouped about this drain pipe. The pipe must leave the house at a point slightly lower than at any other place, and all pipes leaving fixtures must also run slightly down hill. The large and straight pipes are usually iron with the joints tightly closed by means of cement substances, while the smaller pipes are usually lead. In order to prevent odors from de-



An S-trap showing water seal and vent.

caying substances or sewer gas from getting into the house, fixtures known as *traps* are necessary. A study of the figure on page 151 shows that the trap is an inverted siphon, and forms a *water seal* which prevents any gas from going by the water. A good example of such a water seal is seen in the refrigerator trap, where the water seal is used to prevent warm air from getting in to melt the ice.



Why well water is sometimes unsafe.

In the water seal or traps in our houses, the *vent* (see figure) is usually necessary to keep the air pressure equal on each side of the trap, so that the water will not be all sucked out, thus leaving no protection against odors.

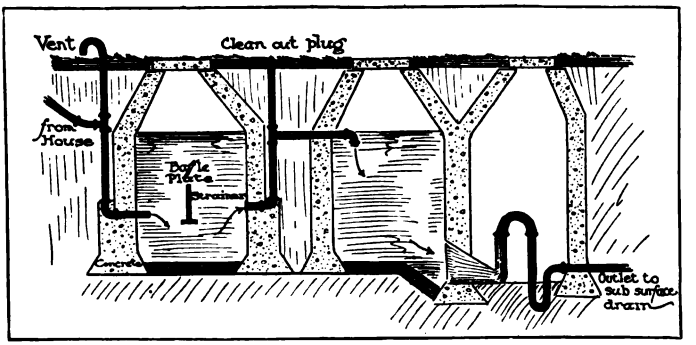
Under the kitchen sink we often find a grease trap. This is fitted, as are all other traps, with a cap which is easily accessible, and which can be unscrewed to remove the grease which otherwise might clog the drain pipes.

Disposal of sewage. — Where there is no city sewage system the disposal of sewage is a most important ques-

tion. In homes where no proper provision is made, we frequently find sewage running into open drains, or even upon the soil, there becoming a dangerous menace to health. Most country homes nowadays have a *cesspool.* This is nothing more or less than a deep hole dug in the earth, having an open bottom, uncemented rock or brick walls and a covered top. It is situated a few feet away from the house, and receives all the sewage which drains out gradually through holes at the sides and bottom into the surrounding soil. If a great deal of water is used, the cesspool is too small, and satisfactory drainage is impossible. Moreover, unless great care is taken, there is danger of drainage into a near-by well. In clayey soils, cesspools give much trouble, as little drainage takes place, and frequent pumping out is necessary. A cesspool should be simply a *temporary* means of getting rid of sewage.

The septic tank. — By far the most modern and hygienic method of sewage disposal is by means of what is known as the *septic tank.* It has been discovered that there are two types of bacteria, one of which (*anaërobic*) thrives without air, releasing oxygen from the substances on which it feeds, and another (*aërobic*) that must have air. The septic tank is made with at least two compartments, both of which are made of cement and are water-tight. In the first compartment sewage from the house flows, and is there attacked by the anaërobic bacteria, which cause the solid matter to become liquid. Fats and other substances rise to the surface, forming an almost air-tight scum, which assists the anaërobic bacteria to do their work more effectively. As the sewage is decomposed it passes into the second tank in an almost colorless and odorless condition. When this tank fills its contents are siphoned off into

drains under the surface of the ground. This sewage is now quite harmless, as all organic contents have been



A septic tank.

decomposed or oxidized by the bacteria, so that no harm can come from it. Several different types of septic tanks are now on the market, and they are infinitely better than the old type of cesspool. The liquid leaving the septic tank contains much valuable fertilizing material, and is generally used on the home garden.

Sanitary garbage pails and their care.—We have already learned that flies feed and lay their eggs in garbage. The garbage pail should be of metal so that it can easily be scalded and should have a tight-fitting cover. During the summer it should be emptied every day or two, as otherwise the bacteria of decay will cause the refuse contained in it to smell badly. If the garbage is not taken up by a collector it ought to be either burned or buried so deep that the flies cannot get at it. If we live on a farm all the fresh garbage should be fed to the pigs or chickens daily. The pail should be kept covered in an inconspicuous place and, as every good housewife knows, should be sterilized with

boiling water and washing soda at least twice a week during the hot weather. If these rules are observed we shall have no trouble from the garbage pail during hot weather.

Use of the score card. — Here again the city boy and girl have an advantage over his or her country cousin. This means more care and an honest attempt to improve conditions on the part of those whose environment is not so favorable. And we must also remember that city conditions are sometimes much worse than country conditions because of lack of repair of fixtures or carelessness on the part of users. So both city and country dwellers may have to make low scores. Remember that, after all, *improvement* is the big thing.

SCORE CARD. REMOVAL OF WASTES FROM MY HOME

	Excellent	Fair	Very Poor	My Score	
					Total
System of Plumbing	Exposed plumbing throughout (2)	Exposed plumbing in bathroom and sink (1)	No exposed plumbing (0)	....	
	All parts of system having traps (toilet, bowl, bathtub, sink, tubs) (2)	Traps at toilet and sink (1)	No traps (0)	....	
	All pipes laid at slight grade (2)		Not all pipes at grade (0)		
	Ventilation ducts provided (2)	Ventilation ducts not always provided (1)	No ventilation ducts (0)	....	
	Trap at house exit (2)		No trap at house exit (0)	....	....
Toilet and Bathroom Fixtures	All porcelain or enameled fixtures, including toilet seat (3)	Porcelain or enameled fixtures, wooden seat (2)	No porcelain or enameled fixtures (0)	....	
	Bathtub, foot tub, and shower (2)	Bathtub, no shower or foot tub (1)	No bathtub (0)	....	
	More than one bathroom (2)	One bathroom (2)	No bathroom (0)	....	
	Lavatory and toilet on ground floor (3)	Lavatory only on ground floor (1)	No lavatory (0)	....	....

SCORE CARD. REMOVAL OF WASTES FROM MY HOME

— Continued

	Excellent	Fair	Very Poor	My Score	Total
KNOWLEDGE OF SYSTEM	Sufficient knowledge of system to (a) Clean out trap (3) (b) Clean out grease trap (3) (c) Repair flush tank float (4)	Knowledge which will give sufficient information to call plumber to (a) Clean out trap (1) (b) Clean out grease trap (1) (c) Fix flush tank float (1)	No knowledge of system. Must call plumber and let him find out the trouble (0)	....	....
SEWAGE CONNECTION	Sewage connection with town or city system (10) Septic tank, properly working (10) (Score only one of above.)	Cesspool (5) Septic tank occasionally giving trouble (5) Outdoor privies if screened and disinfectant used every day (4)	Sewage flows untreated into open drains (0) Outdoor privies not screened or disinfected (0)	....	....
CARE OF GARBAGE AND GARBAGE PAIL	Garbage (a) Collected by city daily (b) burned daily (c) buried at least 2 ft. under surface daily (d) fed to pigs and chickens one day after collection (any method) (3) Metal pail with tight cover (2) Pail emptied daily in summer (2) Pail sterilized twice a week in summer (2) Pail kept in inconspicuous place — no odors (1)	Garbage (a) Collected by city once a week (b) burned once a week (c) buried six inches under surface (d) fed to pigs or chickens once a week (any method) (1½) Metal pail, loose cover (1) Pail emptied weekly (1) Pail sterilized weekly (1) Pail with some odor (½)	No garbage collection (0) Garbage burned every two weeks (0) Garbage scattered over garden in summer (0) Wooden pail, no cover (0) Pail not emptied oftener than once every two weeks (0) Pail not sterilized more often than once every two weeks (0) Bad odor from garbage (0)	....	....
GRAND TOTAL					

REFERENCE BOOKS

Broadhurst, *Home and Community Hygiene*, Chapter VII (Teacher's use). J. B. Lippincott Company.

Butler, *Household Physics*, pages 356–364. Whitcomb and Barrows.

Caldwell and Eikenberry, *General Science*, Chapter XIV. Ginn and Company.

Chapin, *Sources and Modes of Infection* (Advanced and teacher's use). John Wiley and Sons.

Hunter, *A Civic Biology*, Chapters XXII, XXIV. American Book Company.

Lynde, *Physics of the Household*, Chapter VII. The Macmillan Company.

Winslow, *Healthy Living*, Chapter XII. Charles E. Merrill Company.

CHAPTER X

GERM DANGERS AND HEALTH HABITS

Problems. — 1. *To understand the relation of bacteria to disease.*

2. *To discover the defenses of our body against germs.*

3. *To see how habits control our health.*

4. *To learn good health habits.*

This is one pupil's daily program for five days a week.

Experiments. — 1. To show how infection takes place.

2. To make a hygienic drinking cup.

Project I. — To COMPARE MY DAILY USE OF TIME WITH AN IDEAL PLAN.

1. Make two circles with diameters of $3\frac{1}{2}$ inches. Just inside the circles put in two series of figures, 1 to 12, equally spaced to represent the twenty-four hours of the day. (See diagram.)

2. In one of these mark out the spaces representing time given to various things suggested as ideal.

3. Keep a record of your own habits in these matters for one week. Average these, and on the basis of the averages fill out the second circle to represent your own daily schedule.

Project II. — To form correct health habits.

Join the "Health Crusaders." Perform their assigned tasks regularly and make proper records. Keep a monthly record as suggested by the following table.

PHYSICAL EXAMINATION

Monthly Record	1	2	3	4	5	6	7	8	9	10
1. Weight . .										
2. Height . .										
3. Chest measure										
(1) Inflated .										
(2) Deflated .										
(3) Chest expansion = (1) − (2) . .										
4. Lung capacity										
5. Time can hold breath .										
6. Eye test . .										
7. Hearing . .										
8. Grip test . .										
9. Lifting strength . . .										
10. Age . . .										

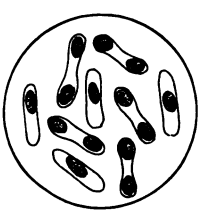
Where germs live and how they grow. — Some one has said that bacteria exist "anywhere but not everywhere." They swarm in soils, in impure water, in stale milk, in the dead bodies of plants and animals, and to a certain extent in living bodies as well. They cause decay, and so far as we know, all "catching" diseases. We could tell many other things they do, and we have already seen some of them.

What bacteria look like. — It is easy to see the effect of bacteria on milk when it sours and on food when it decays, or to observe colonies of them growing in a Petri

dish, yet each bacterium is so small that it is visible only under a very high power microscope. Bacteria are single-celled plants, unable to make their own food, and con-

Types of bacteria. 1. Rods. 2. Spheres. 3. Spirals.

sequently do much harm by living at the expense of other things, as upon dead organic material. Some one has said that in order to recall their forms one must think of a billiard cue, a billiard ball, and a corkscrew. A glance at the illustration will show how true this statement is. They are rodlike (called *bacillus*), ball-like (called *coccus*), or spiral (named *spirillum*) in form. Many kinds can move with great speed through the water by means of tiny threadlike structures which vibrate rapidly. They never thrive except in moisture, although some of them may be dried and float around in the air some time without dying, becoming active again when moist. Many forms endure an unfavorable environment of heat and cold as well as dryness by forming a thick resistant coat about their body. In this condition they are called *spores*.



Bacteria forming spores.

How germs cause disease. — It has been estimated that over fifty per cent of the people who die each year are

killed by bacteria. A very large portion of the infectious diseases might be prevented if people knew more about the ways by which germs enter the body and were more careful to keep them out. It may help us to see how germs get into the body if we study the way in which an apple is protected against infection and by what means it is infected.

Experiment. — To show how infection takes place.

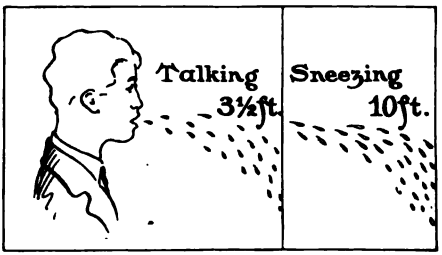
Materials: A sound apple. A decaying apple. Toothpicks.

Method: (*a*) Make a small irregular hole through the skin of the sound apple. Fill this with decaying pulp from the other apple. (*b*) Stick a toothpick into the rot of the decaying apple and then stick it into the sound apple, leaving it there. (*c*) Sterilize a toothpick by passing one end of it through a flame several times without allowing it to take fire. Stick this end of the toothpick into the apple and leave it. (*d*) In a four-inch area on the unbroken and unbruised skin of the sound apple lay a little of the decaying apple pulp. Set the apple away in a dark, warm place.

Observation and Conclusion: Examine the apple daily until changes have occurred in one or more of the places. Where does infection occur? Explain what natural defense against infection the apple has, but how conditions may arise in which decay results.

Methods of infection. — When we take germ diseases the germs enter our bodies by means of the nose, mouth, through body openings, or through a break in the skin. They may be carried by means of food, water, or even through the air, and the germs usually are taken directly from a person who has the disease. The most common method of spreading disease is by sneezing or coughing, or even breathing and talking close to the face of some one else. If you have ever watched a person talk when in the sunshine, you may have observed a constant spray of tiny droplets which are forced out from the mouth. These droplets are sprayed from two to three feet from the

mouth of the person. Most children's "catching" diseases begin with sore throat, sneezing, and coughing. Measles, whooping cough, scarlet fever, tonsillitis, influenza, and diphtheria all begin in this way, hence it is very easy for any one unthinkingly to spray out the germs when coughing, sneezing, or even talking, and thus to infect some one else. A good health habit to form very early in life is that of the proper use of the handkerchief. Never cough or sneeze into the open air, but into a handkerchief. Keep the nose well blown to prevent an unpleasant appearance as well as possible spread of colds. A "common cold" soon becomes everybody's cold in a schoolroom in which the children do not have the proper health habits. A good rule to observe with reference to colds is this: remain quietly at home resting in bed, for thus one will not only prevent others from "catching" it, but by rest and proper food it will soon be cured.



A common method of spreading germs. (After Winslow.)

Disinfectants and how to use them. — Sometimes it becomes necessary in our homes to destroy the bacteria which cause disease. This is done by the use of disinfectants. Many different substances which have a deadly action on bacteria can be obtained at the drug store. Inasmuch as these substances, such as carbolic acid, lysol, bichloride of mercury, and formaldehyde, are deadly poisons, we must exercise the greatest care in their use. For disin-

fecting wounds or cuts iodine is much used; while for use on hands, a weak (1 to 25 parts water) solution of carbolic acid followed by scrubbing with green soap is safe and sure.

Our body defenses against disease. — Germ diseases are usually caused by poisonous *toxins*. These are waste materials given off by bacteria which act upon the individual like snake venom. Some people are very much more resistant to these toxins than others, and therefore are less likely to take "catching diseases." This resistance to or defense against disease, when powerful enough to kill the germs or offset the harm from toxins, produces an *immunity*. Immunity may be natural, or it may be acquired in the case of some diseases. This, for example, is done in the case of diphtheria by means of *antitoxin* treatment, and in the case of small pox and typhoid, by means of *vaccination*. The theories underlying immunity will be discussed more fully in the next book. Natural immunity, however, may be increased by keeping the body in just as good condition as possible. Proper habits of health as suggested in the following paragraphs will assist greatly in maintaining one's health.

Air and health. — We have already referred to the need of oxygen. It is generally agreed at the present time that we must have as much fresh air as possible, that our rooms must be well ventilated, that porous clothes must be worn so that the body can have a constant air bath, for the skin under the clothes needs air as well as the parts exposed. We have come to depend upon outdoor play and outdoor sleeping as means of good health. We should always practice good posture and acquire good breathing habits. An excellent habit is that of morning exercise with the windows thrown open. Remember that the lungs need exercise

Simple foods are nourishing.

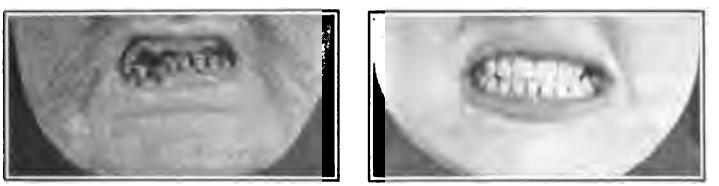
Indigestible foods.

Bulky foods. (Eastman Kodak Co.)

and air, and that only by deep breathing which expels much of the stagnant air which accumulates in the lungs can we make them resistant against disease germs.

Food and health. — Boys and girls should eat enough, but not too much. They should not eat when very tired, and should eat only a light meal at night. Hard and bulky foods should be included in the menu, since they tend to prevent constipation. Raw foods containing vitamines should always be a part of the diet, especially uncooked milk, fresh fruits, and fresh vegetables, but all raw foods should be carefully washed because of danger from germs.

Care of the teeth. — Thorough chewing of the food is necessary for good health. Many of us bolt our food, and as a result suffer from indigestion. The teeth are important factors in the habit of proper chewing. We can form no better habit than that of properly brushing them. The teeth should be brushed at least twice a day, and not only the teeth but also the gums around them. Brushing up



Results of neglect and care of teeth.

and down rather than across the teeth is of much more value, because it dislodges the food particles held between the teeth, and thus prevents their decay. The teeth should be examined by a dentist at least twice a year, for this will save much pain and possible loss later on. Decay of the

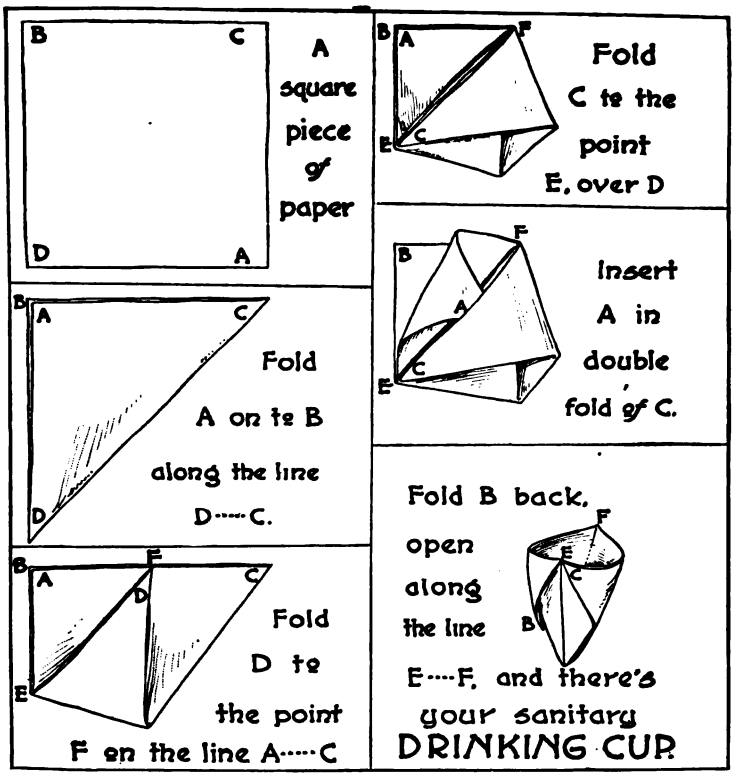
teeth comes as a result of bacteria lodging in the same crevices with food. They pour out an acid waste substance which attacks the hard enamel of the teeth, breaking it down and thus allowing germs gradually to attack the living portion of the teeth underneath. Upon our teeth depends much of our health later on in life, so let us form habits of proper care of them while we are young.

Body poisons and good health. — One of the best habits to get early in life is that of regularity of bowel movement for thus we may be spared the evils which come through constipation. As we have studied before, the lower part of the food tube, if not emptied regularly, becomes filled with decaying material, for this part of the food tube is always alive with millions of bacteria, which cause decay. As this decay takes place, the soluble poisons set free are easily passed through the wall of the bowels and get into the blood, causing headache and a feeling of discomfort which often attends constipation. Excellent suggestions which will help us to fight this evil are the following. Drink a glass of water when you get up in the morning, and at least one glass before each meal. Take plenty of raw or cooked fruits except bananas, blackberries, and raspberries. Green vegetables, whole wheat bread, bran muffins, fats, and oils are helpful in keeping the bowels regular. Avoidance of tea and coffee, and proper hours of sleep, all help in fighting this evil.

Drink six glasses of water a day.

Get the habit of using your own cup when you drink. Every one should know how to make his own drinking cup.

Follow the directions given in the accompanying diagram, and see if you can make yours.



(After Tolman.)

Experiment. — **To make a hygienic drinking cup.**
Materials: A sheet of strong clean paper six to eight inches square.
Method: Fold as suggested in the accompanying diagram.

Exercise and health. — Most boys and girls may exercise enough, but not properly. Especially in the case of girls, proper posture, or poise of the body, in walking, sitting,

and standing, is necessary. The bad habit of sprawling over the desk or table when at work makes for round-shouldered, small-chested men and women. Learn to set the shoulders square and back, keep the chest high and out, and both the stomach and chin in. Military training, such as our young men have had in the great World War, has done much to increase their bodily resistance to disease, and to make strong men of weaklings.

HOME DUTIES OF CHILDREN

My Own Record	Time. Minutes per Day	Score
1. Sweeping and dusting general rooms		
2. Full charge of own chamber		
3. Making beds		
4. Helping cook		
5. Ironing		
6. Preparing wood and kindling		
7. Building fire regularly		
8. Taking care of furnace		
9. Taking care of hens and chickens		
10. Tending baby		
11. Taking care of a pet: dog, cat, bird, fish, or rabbit		
12. Taking care of garden and lawn		
13. Shoveling paths		
14. Setting tables		
15. Washing dishes, running errands		
16. Other work		
TOTAL		

Copy this form of record in notebook.
Register average time per day given to work here listed.
A total of 10 points for every 15 minutes devoted to any duty daily.
Boys and girls will score extra work not mentioned here under 16. No score allowed over 100. Two and one half hours daily home work outside of school work entitles you to a perfect score.

Home duties. — Every boy and girl ought to have a part in the duties as well as the pleasures of the home. It is unfair to mother and father to have them assume all the care of the house, and it ought to be part of your

training to have a practical knowledge of how the house is made to run smoothly. Besides this, there is a certain amount of healthful exercise in weeding the garden or cleaning the walk or bringing up the coal or running a sewing machine or a churn. The score card on page 168 will give you some idea of how well you are living up to your part of the home duties.

Rest and health. — Our days should be made up of work and play, rest and sleep. It is just as bad to over-exercise, as it is to under-exercise. One should remember that all machines need rest, and the human machine is no exception to the rule. At least eight hours of sleep should be had by every boy and girl of high school age, and nine or ten hours of sleep by younger children. Fewer movies and more quiet reading at home would be good for every boy and girl. Moderation in all things is a good rule. Overstrain of any kind brings on fatigue, and in the end shows that we cannot strain an organ without paying for it. If we overstrain the eyes, for example, we pay for it by wearing glasses later. If we overstrain in athletics, we may have to give up athletics altogether. Over-fatigue by keeping too late hours will surely call us to account later in life. Let us learn while young the value of complete relaxation, and let us, while we are growing, get the habit of going to bed at the proper hour.

Time for sleep.

Habits of cleanliness. — "Cleanliness is next to godliness" is an old saying, and a good one. Habits of cleanliness at meals are particularly necessary. One should always wash the hands after going to the toilet. Bathing

the entire body at least once a week should be a habit, and if the feet or body become covered with perspiration in warm weather, one should bathe more frequently.

Always wash the hands before eating. (Eastman Kodak Co.)

Not only should we get the habit of cleanliness of body, but we should also early in life strive for habits of cleanliness of mind. We should learn to keep watch upon our thoughts as well as upon our bodies, for purity of mind as well as purity of body will have an effect on health as well as an influence over others.

The use and abuse of drugs. — One degrading habit to which Americans are addicted is the use of patent medicines and drugs. American newspapers annually receive fully $40,000,000 for advertising patent medicines; how much more must the manufacturers of these medicines receive? It should be a rule never to use a patent medicine unless it is prescribed by our physician. The body is a delicate

machine, and easily put out of running condition. If it is out of order a physician should be consulted, and one should not try to "doctor" himself. Boys and girls should not drink tea and coffee. Cocoa and milk are better beverages, as they are food substances; while neither tea nor coffee have any food value, and are dangerous for young people because they are apt to make them form the habit of drinking tea and coffee to excess. It goes without saying that alcohol in any form should not be used. Tobacco has been proved to have a bad effect upon growing boys. Dr. Seaver of the physical training department of Yale College some years ago made a careful comparison of the growth of smokers and non-smokers during their four years in college. He found that students who did not

Alcoholic drink, tea, coffee, and tobacco are especially harmful during the years of bodily growth.

use tobacco gained ten per cent more in weight, twenty-four per cent more in height, twenty-seven per cent more in chest expansion, and seventy-seven per cent more in lung capacity than did the smokers. The tobacco heart of

smokers is well known to the athlete, and no boy who is in training can have any doubt that the use of tobacco has a definite effect on his "wind" when he trains for some athletic contest.

Fifteen health rules. — One of the most interesting and helpful books written in late years is the manual, *How to Live*, by Professor Irving Fisher and Dr. E. L. Fisk. They summarize the health habits given in this chapter in the following fifteen rules:

I. AIR:

1. Ventilate every room you occupy.
2. Wear light, loose, and porous clothes.
3. Seek out-of-door occupations and recreations.
4. Sleep out of doors, if you can.
5. Breathe deeply.

II. FOOD:

6. Avoid overeating.
7. Eat sparingly of meats and eggs.
8. Eat some hard, some bulky, some raw foods.
9. Eat slowly.

III. POISONS:

10. Move the bowels regularly and frequently.
11. Stand, sit, and walk erect.
12. Do not allow poisons and infections to enter the body.
13. Keep the teeth, gums, and tongue clean.

IV. ACTIVITY:

14. Work, play, rest, and sleep in moderation.
15. Keep happy.

Welfare pamphlets. — Much help in forming good health may be obtained from the welfare pamphlets such as those issued by the Metropolitan Life Insurance Company and the International Harvester Company. Several of the illustrations in this chapter were taken from "Good Health

and How to Keep It," issued by the Eastman Kodak Company for the benefit of its employees.

How to score my health habits. — Everyday life is nothing but repetition of things over and over again. And that means our everyday life becomes habitual. One great thinker and teacher has said that we are "bundles of habits." Certainly our daily routine ought to be largely a matter of habit and of *good* habits. Therefore we should take no score whatever unless each point mentioned has become a matter of habit. There ought to be a good many points that you can add to this score card, some of which may be of more importance than the ones on the card. Be sure to add these and bring them to class for discussion. Perhaps by all working together you can make an ideal card, much better than the one which follows.

SCORE CARD. PERSONAL HEALTH HABITS

	Perfect Score	My Score
Regular daily routine	5	
Setting-up drill and deep breathing	5	
Cool rub or shower	5	
Teeth brushed morning and night	5	
Slow eating at meals	5	
Food chewed well	5	
No overeating	5	
Cheerfulness at meals	5	
Regular toilet habits	5	
Wash hands often, always after toilet	5	
Clean shoes and clean linen	5	
Loose, comfortable clothing	5	
Feet warm and dry	5	
Regular play hours	5	
Exercise in open air two hours a day	5	
Regular work and study hours (at least two hours)	5	
Proper lighting for study	5	
Bed before 10 P.M.	5	
Sleep in open air or with windows open top and bottom	5	
No coffee, tea, or cigarettes	5	
TOTAL	100	

SCORE CARD. PROTECTION AGAINST DISEASE

	Perfect Score	My Score
Vaccinated for smallpox	5	
Teeth examined twice a year	5	
All cavities filled	5	
Eyes examined once a year	5	
Glasses used when necessary	5	
Keep more than five feet distant from those who cough or sneeze	5	
Take care to use handkerchief if you cough or sneeze	5	
Stay in the house if you have a cold	5	
All clothing clean and sterile at all times	5	
Wounds properly disinfected	5	
TOTAL	50	

REFERENCE BOOKS

Adams, *The Great American Fraud*. American Medical Association.

Broadhurst, *Home and Community Hygiene*, Chapter X (Teacher's use). J. B. Lippincott Company.

Brownell, *General Science*, Chapter III. Blakiston's Son and Company.

Chapin, *Sources and Modes of Infection* (Teacher's use). John Wiley and Sons.

Clark, *An Introduction to Science*, Chapter XX. The American Book Company.

Conn, *Bacteria, Yeasts and Molds of the Home*. Ginn and Company.

Conn, *Story of Germ Life*. D. Appleton and Company.

Dakin and Dunham, *Handbook of Antiseptics* (Advanced). The Macmillan Company.

Dorset, *Some Common Disinfectants*. Farmers' Bulletin 926.

Fisher and Fisk, *How to Live*. Funk and Wagnalls.

Harmfulness of Headache Mixtures. Farmers' Bulletin No. 377.

Habit-Forming Agents. Farmers' Bulletin No. 393.

Hill, *The New Public Health* (Teacher's use). The Macmillan Company.

Hunter, *A Civic Biology*, Chapters XI, XXIV. American Book Company.

Hunter, *Laboratory Problems in Civic Biology*, Chapter XI. American Book Company.

Jewett, *Good Health*. Ginn and Company.

Lee, *Health and Disease* (For teachers). Little, Brown, and Co.

Prudden, *Dust and its Dangers*. G. P. Putnam's Sons.

Ritchie, *Primer of Sanitation*, Chapters XXXI, XXXII. World Book Company.

Van Buskirk and Smith, *The Science of Everyday Life*, Project IV. Houghton Mifflin Company.

Winslow, *Healthy Living*. Charles E. Merrill Company.

Zinsser, *Infection and Immunity* (For teachers). The Macmillan Company.

PART III. HEAT IN THE HOME

CHAPTER XI

FUELS AND THEIR USES

Problems. — 1. *To learn about fuels and their relative values.*

2. *To find out what burns in fuels.*

3. *To learn the difference between "heat" and "temperature."*

4. *What is the kindling temperature?*

5. *How is heat transferred?*

Experiments.

1. To find out if all substances take fire at the same temperature.
2. To see if heat will travel along a metal rod.

Project I. — To MAKE A HOUSE THERMOMETER.

1. Decide what materials are needed, and whether you will make an alcohol or a mercury thermometer.

2. Practice glass working so that you can blow bulbs in common glass tubing before trying thermometer tubing. Do not try tubing with a bore smaller than one millimeter.

3. The essential operations to learn are: making the bulb, filling it, sealing, and making a graduating scale.

Suggested Projects.

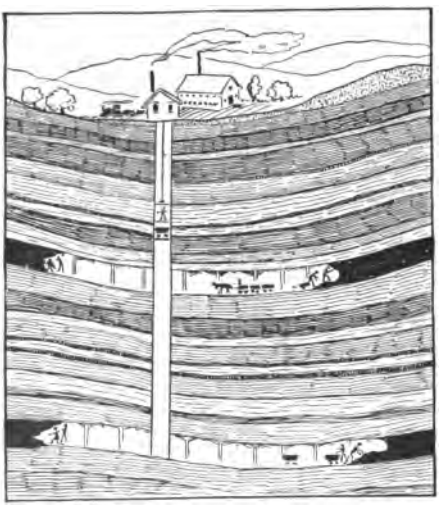
1. ARE THE FUELS AT HOME COSTING TOO MUCH? ARE THEY USED EFFICIENTLY?

2. To make an ordinary safety match.

3. To make a fire by primitive means without matches, burning glass, or flint and steel.

4. Different methods of building a fire and regulating it when built.

Sources of fuel.—Everybody is familiar with the materials used commonly as fuels such as coal, gas, oil, wood, and alcohol. Most fuels come originally from plants, that is, they are organic in origin. Coal, which seems like rock, is really nothing more or less than gradually transformed bodies of dead plants. Prints of leaves and sometimes whole trunks of trees all now transformed into coal are found in coal mines. Specimens of them may be seen in our museums. Millions of years ago vegetation became collected in swamps, sank into the earth, and other materials came to lie over this mass of organic matter. Then came pressure, heat, and moisture acting together on this plant material, gradually driving off some of it and leaving a hard substance made up very largely of the element *carbon*. In some places similar swamps exist now and are called peat bogs, a poor kind of fuel being dug from them, which,



Coal beds in the earth.

after drying, may take the place of coal or wood. It is believed by many scientists that petroleum and natural gas are also formed through slow chemical changes from dead bodies of plants and animals buried millions of years ago. Great areas holding gas and oil have been discovered in different parts of the United States, the largest production coming from Pennsylvania, West Virginia, Indiana, Texas, California, Oklahoma, and Illinois. Mexico has fields of great value, and oil is found in paying quantities in other parts of the world, southern Russia being one of the richest areas.

In an oil region.

Economy and burning value of different fuels. — Wood is used the world over, and is probably used now in more homes than any other fuel. Hardwood, such as hickory, oak, maple, or beech, burns longer and gives a steadier heat than softwoods, such as poplar, hemlock, or pine, but softwoods give off heat more quickly. Coal is a much used fuel in our eastern homes, soft coal being used more where it is abundant. Soft coal is much dirtier, but somewhat cheaper than hard coal, or anthracite. Coke, which is coal from which certain gases have been removed, is valuable

for a quick and hot fire. Natural gas, where abundant, is both cheap and an excellent fuel, while artificial gas has come into many homes to be used as an ideal fuel for cooking. Some homes, indeed, have come to use electricity, and it is believed by scientists that when our great coal and oil resources have been exhausted, we shall depend still more upon electricity produced from water power as a source of heat in our homes. An interesting home project would be a study of the costs of the fuels used in your own home. Fill out a table like the one shown below,

FUELS USED IN MY HOME

Fuels	Amount	Date Purchased	Cost	Use

giving the kind of fuel, the amount bought on each date, and for what purpose the fuel is used. Is it more economical to buy in small or large quantities? A study of the second table on a comparison of fuels shows that different fuels have a very different heating value, but as their cost in the different localities differs so greatly, this table would have to be modified by each boy and girl who uses it, for his own locality.

Heating value of fuels. — It is of some interest to compare the available heat produced by different fuels. In the following table is shown the amount of water which can be heated from the freezing point to the boiling point for one cent at specified prices, provided *no heat is lost.* It is understood, of course, that no heating device will

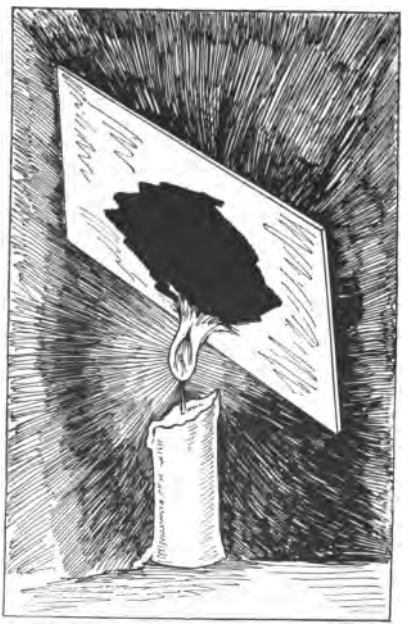
QUANTITIES OF HEAT OBTAINED FROM VARIOUS FUELS FOR ONE CENT

Fuel	Price	Gallons of water heated from freezing to boiling point *if no heat is lost.*
Soft wood	$15.00 per cord	14
Hard wood	16.00 per cord	20
Soft coal	10.00 per ton	17
Hard coal	15.00 per ton	13
Coke	12.00 per ton	13
Charcoal	80.00 per ton	2.6
Kerosene	.20 per gal.	4.1
Natural gas	.50 per 1000 cu. ft.	13
Manufactured gas	1.50 per 1000 cu. ft.	2.8

give one hundred per cent efficiency in the burning of fuel, so in practice, you could not heat as much water to the boiling point as is indicated by the table above.

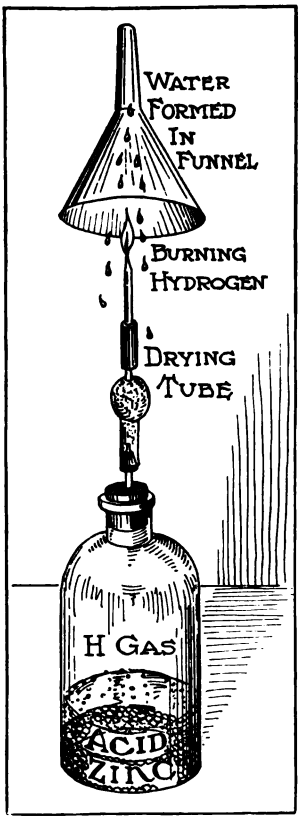
If you wish to heat only a kettle full of water the coal range gives much less efficient service than the gas range, even though gas may cost more for a given number of heat units. Do you see why this is?

What is it that burns in fuels? — If you hold a clean glass plate in the flame of a candle, you will notice a thick, black deposit gather on that part of the plate exposed to the flame. This ma-



Carbon from a candle.

terial is almost pure carbon. A little thought must convince one that it comes from the candle. If we hold a well-dried funnel over the candle flame, we find drops of moisture on the inside of the funnel. We know the water did not come from the air, because no water settled on the walls of the funnel before the candle was placed under it, therefore we conclude that a burning candle produces water. If we now make some hydrogen gas by pouring a little hydrochloric acid over zinc, and then pass it through a drying chamber as shown in the diagram, we can burn the gas in air. Let us before lighting the gas allow it to pass for two or three minutes into a dry, cold funnel. Watch the inside of the funnel carefully. Does anything happen? Now light the colorless gas and invert the funnel over the flame as before. You will notice that water appears on the inside of the funnel. Since water is formed both by the burning of the candle and the burning of hydrogen, it appears that hydrogen is also in the candle. All fuels contain carbon. Most fuels contain carbon and hydrogen as well, and many contain other substances in addition.

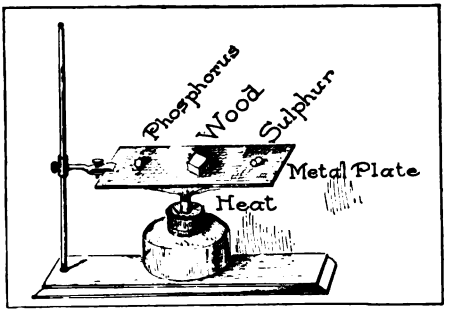


Water is a product of burning hydrogen.

Experiment.—To find out if all substances take fire at the same temperature.

Materials: Tin plate or sheet iron. Sulphur. Phosphorus. Wood. Ring stand. Clamp. Burner.

Method: Support the sheet iron horizontally with a clamp attached to ring stand. Place a few short pieces of wood (broken match stems) on the middle of the iron plate, and two inches distant from this place on one side a lump of sulphur the size of a pea, and on the other side a piece of phosphorus the size of a rice grain. (Do not handle phosphorus with the bare hands and always cut it under water.) Place a low flame under the middle of the iron. The iron distributes the heat so quickly that we may assume that all the materials are being warmed equally at the same time. Each time one burns we may turn the heat on a little stronger.

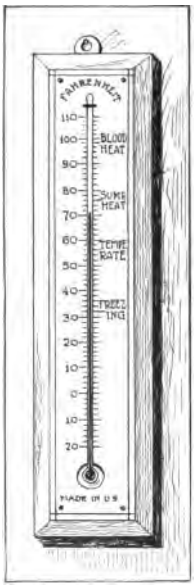


Observations: Note the appearance of smoke, the melting of the substances, and the order of taking fire.

Conclusion: The temperature at which a substance takes fire is known as the kindling temperature. What does this experiment show you in regard to kindling temperatures of sulphur, phosphorus, and wood?

The kindling temperature.—It is evident that different substances take fire at different intensities of heat. The intensity or degree of heat is called *temperature.* In the experiment, we found that the phosphorus burns first, then the sulphur, while a much higher flame is necessary to make the wood burn. Evidently some substances kindle at a much lower intensity of heat than others. If we now use a thermometer, an instrument used for detecting different intensities of heat, or temperatures, we can find the exact kindling temperatures of many substances.

How temperature is measured. — What do we mean by temperature? We are aware that our bodies are warm, and that ice is cold. Measured in degrees of temperature, the body is 98.6 degrees, while melting ice is 32 degrees Fahrenheit. The common house thermometer is an instrument consisting of a fine bore, sealed glass tube with a bulb at the lower end. Mercury or colored alcohol fills this bulb and extends part way up the tube. As heat makes mercury expand, it rises in the tube when it gets warmer, and degrees of temperature are marked on the thermometer (see diagram). There are two kinds of measurements, the one used by scientists, known as the Centigrade scale, while the Fahrenheit scale is used in this country for ordinary purposes. Thermometers have come into very general use, and we should all know how to read them and understand what they mean. They are useful as regulating devices in cooking, as we often find them in the oven doors. We also use them for regulating the temperature of our rooms. The room temperature should never be allowed to go over 70 degrees Fahrenheit in winter



House thermometer.

Clinical thermometer.

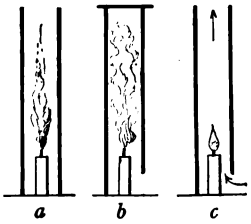
and the air should not be allowed to get dry, as such conditions increase our liability to colds when we leave the house to go out of doors. One type of thermometer has

become a household necessity. This is the clinical thermometer which is used in order to detect any change in the temperature of the body from normal, or 98.6 degrees. Body temperature changes are the surest indication that something is wrong within, for fever always shows the presence of toxins or poisons in the blood, and may mean serious illness. In case of a high temperature or fever a physician should always be called.

Study of a match. — Fire making has improved greatly since the days when the Indian rubbed a pointed stick into a hole in another stick in order to obtain a light through the heat evolved by the rapid rubbing or friction. The flint and steel of our forefathers made use of percussion in obtaining fire, and the modern friction match makes scientific use of the different kindling temperatures of different substances. We have seen that phosphorus kindles at a lower temperature than most substances, but white phosphorus is poisonous and its use in making matches has been prohibited by law, so that the ordinary match head now contains a mixture of a phosphorus compound combined with potassium chlorate, powdered glass or sand, and glue. By rubbing this enough heat develops so that it lights. In the safety match the head is made up of some substance that burns at a low temperature while red phosphorus is placed on the box, combined with sand or powdered glass to give it a rubbing surface. This prevents the match from being lighted without the phosphorus on the box to aid it in its ignition.

How to make a fire. — The following simple experiment will show one factor necessary to start a fire. Cover a burning candle with a lamp chimney so that it is closed at the bottom but open at the top. The candle gradually

goes out. Now cover the lamp chimney with a piece of cardboard and bring it over the lighted candle again, but leave an open space under the chimney. Again the candle goes out. Light the candle and place the chimney over it, leaving the chimney open at both top and bottom. The candle burns.

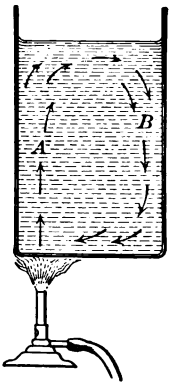


a, No air inlet; *b*, No air outlet; *c*, Has both inlet and outlet. This gives a good *draft*.

A study of the burner of a kerosene lamp shows that air passes in, as in the case of the candle, underneath the flame, and passes up out of the top of the chimney. By holding the hand, or by placing a small light object over the top of the chimney, the passage of air is noticed. The burner of a lamp regulates the air supplied to the flame, which goes out if the air supply is cut off, as was shown in the case of the candle. Evidently a current of air is necessary to make fire burn. These currents which are in circulation after the fire starts are known as *convection currents*, and as we shall see in a moment, are important factors in heating our homes. In order to start a fire in the kitchen stove or open fireplace, we put in a piece of paper and cover it with some shavings

How air circulates in the common oil lamp. (After Clark.)

or fine kindlings, and a few small sticks on top in such a way that air can circulate around the fuel. Light the paper at the bottom and the fire is started. If we were to shut off the upper draft in the pipe by closing the damper, or if we were to close the lower door in the stove so as to cut off the current of air from below, the fire would smolder and go out. Air with its constant supply of oxygen is necessary to keep a fire burning. We say the hot air rises. But, as a matter of fact, warm air is lighter than cold air and the cold air is pulled downward with such force by gravity that the warm air is crowded out of the way. Thus smoke made up largely of hot gases is pushed up the chimney.



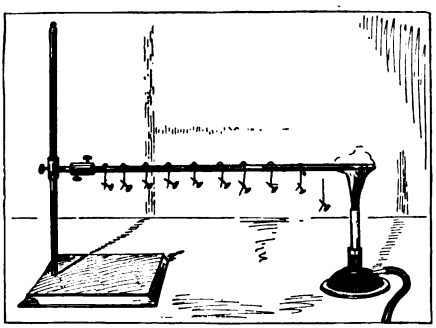
Convection currents in a vessel of water.

Three methods of distributing heat. — We have all seen that heated currents of air are carried up by *convection*. Thus heat is moved about in the room by means of currents of air. The air as it moves gives heat to cooler bodies, and thus to a great extent the rooms of our houses are warmed. But heat also moves through space where there is no air. We all know that the sun keeps us warm, but do we all know that its heat travels through vast areas of space in which no air exists? This space is filled with ether, and through the ether heat moves by means of waves. This method of heat transference is called *radiation*. Some surfaces absorb heat much more rapidly than others. Scientists know that black or dull substances do this much better than light or shiny substances, and substances which absorb heat readily give it up easily by radiation. May this be a reason for our black

stoves and dull radiators? Still a third method of heat transference is the passing of heat from one particle of material to another. This is called *conduction*. A very interesting experiment shown in the figure illustrates this method of heat transference. The heat received by one set of particles is passed on to others, and by them to still others. Most metals are very good conductors. Some substances, like glass, water, and many rocks, are fair conductors, while air, wood, paper, and linen, silk, and woolen fabrics are poor conductors. This principle of non-conduction is used in making the fireless cooker, the thermos bottle, and the ice chest, where the heat is kept inside in one case, and outside in the other. Solids are the best and gases the poorest conductors of heat, air being one of the best heat-insulating (non-conducting) materials. Convection can take place only in liquids and gases. Remember that all these methods of transference of heat are at work in heating our homes.

Experiment. — To see if heat will travel along a metal rod.

Materials: A metal rod 15 to 20 inches long. Ring stand and clamp. Burner. Wax. Thread.



Method: Tie a short thread to each of six tacks. Attach these two inches apart to the metal rod by means of melted wax. Support the metal rod so that one end is in the flame of the Bunsen burner.

Observation: Notice the order of the melting of the wax and dropping of the tacks. What does this suggest?

Conclusion: What does this experiment teach about conduction of heat?

REFERENCE BOOKS

Allen, *Sweden and Safety Matches*. Ginn and Company.
Ashmead, *The Man Who Mines our Coal*. Scientific American, May 18, 1918.
Barber, *First Course in General Science*, Chapter I. Henry Holt and Company.
Clark, *An Introduction to Science*, Chapters I, II, IV. American Book Company.
Cleland, *Geology, Physical and Historical*, Chapter XVI (For teachers). American Book Company.
Fall, *Science for Beginners*, Chapters XI, XXV. World Book Company.
Faraday, *Chemical History of a Candle*. Harper Brothers.
Forman, *Stories of Useful Inventions*. The Century Company.
—— *The Efficient Use of Coal*. Century, February, 1918.
Greene, *Coal and the Coal Mines*. Houghton Mifflin Company.
Hodgdon, *Elementary General Science*. Hinds, Hayden and Eldredge.
Lynde, *Physics of the Household*, Chapters VIII, IX, X. The Macmillan Company.
Maron, *The Origin of Inventions* (Fire making). Charles Scribner's Sons.
Mumper, *Text-Book in Physics*. American Book Company.
Routledge, *Discoveries and Inventions of the Nineteenth Century*, pages 646–652. Routledge.
Stone, *Making a Match*. General Science Quarterly, Salem, Mass., January, 1919.
Tappan, *Makers of Many Things* (Matches). Houghton Mifflin Company.
Toothaker, *Commercial Raw Materials* (Coal and Oil). Ginn and Company.
Van Buskirk and Smith, *The Science of Everyday Life, Project II*. Houghton Mifflin Company.
Venable, *History of Chemistry* (For teachers). D. C. Heath and Company.
Whitman, *How to Make a Thermometer*. General Science Quarterly, May, 1920.

CHAPTER XII

HEATING OUR HOMES

Problems. — 1. *To see how our homes are warmed.*

2. *To find out how heating devices are constructed.*

3. *To learn the best way of regulating the fire in the stove or furnace.*

4. *To see how heat is used in cooking.*

5. *To understand how the hot-water supply system is operated.*

6. *To learn how to find the amount of gas consumed.*

Experiments.

1. To show the principle of hot-water heating.
2. To show the great amount of heat stored in steam.
3. To show how to produce luminous and non-luminous gas flames.

Project I. — TO QUALIFY AS AN EXPERT HEATING DEVICE OPERATOR IN MY HOME.

1. To start fires quickly *without use of kerosene.*

2. To control the fire properly: to keep the house evenly heated; to have the oven at the proper temperature at the right time.

3. To increase the humidity of the air when needed, and to secure ample ventilation.

4. To adjust the air mixer on gas burners.

5. To clean out clogged and dirty gas burners.

6. To prevent needless heat loss from any cause.

7. To prevent the existence of fire hazards from any heating device.

Project II. — TO LEARN HOW MY COAL RANGE IS CONSTRUCTED AND HOW TO RUN IT.

Study coal range at home. Find out what the different parts are for and how they are related to each other. Make a cross section diagram across the fire box and oven. Use arrows to show circulation of gases from room to stovepipe when oven is being heated. Use dotted lines to suggest necessary passages which would not show in cross section. Make a chart like the one below and fill in the blank spaces, indicating how you would regulate fire to meet different conditions. Include the following table completed in your report of this project.

	DRAFT IN ASHPIT DOOR. (A)	SLIDE IN FUEL DOOR. (B)	DAMPER ON STOVEPIPE. (C)	CHECK DRAFT IN STOVEPIPE. (D)
Starting a fire				
Keeping a moderate fire . . .				
Cooling an overheated stove . .				
To keep a fire overnight . . .				

Additional Projects.

1. TO DETERMINE HOW MUCH FUEL CAN BE SAVED BY USING A FIRELESS COOKER FOR COOKING CERTAIN FOODS.
2. TO UNDERSTAND THE HOT-WATER SUPPLY IN MY HOME.
3. TO UNDERSTAND HOW HEAT IS TRAPPED IN A SUN PARLOR, AND COLD FRAME.

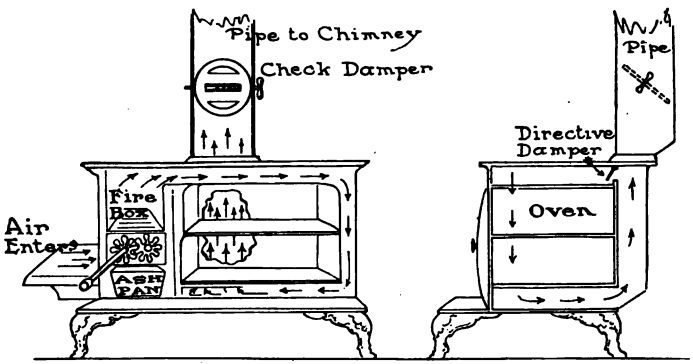
Thought Question.

1. Why does not the cold water enter the hot-water tank through a pipe at the bottom of the tank rather than through the one from the top?

How heat is used in our homes. — Without heat for warming our houses and cooking our foods, home would be a dreary place. We do not always appreciate the hot, well-cooked dinner, warm rooms, and the cheerful fireplace

because these things have long been commonplace. Heat has become a servant of man, and fire is harnessed in many ways that would be strange to our forefathers. As good home makers, we should learn about the devices used for heating and cooking in the home.

The coal stove. — The ordinary coal stove used for heating or cooking is really a metal box arranged so as to admit air for combustion, and to carry the products of

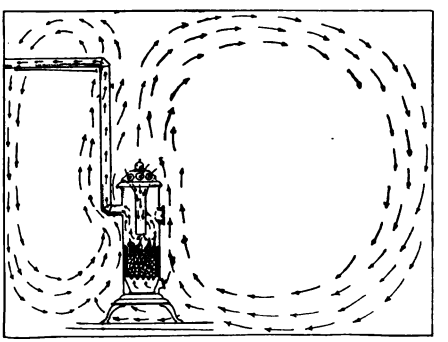


The coal range. Point out the place for the check draft.

combustion up the chimney. The coal rests on the grate and is burned in the *fire box*. Below the grate is a compartment to hold ashes, called the *ash pit*. Each compartment has a door with openings and slides in it. The openings in the lower door form the *draft*, and those in the upper door the *check draft*. In the stove pipe, which leads to the chimney, there is another device for controlling the air currents called the *damper*.

Regulation of fire. — In starting the fire, the lower draft and the damper should be open, but the check draft should be closed. This allows the poisonous carbon monoxide

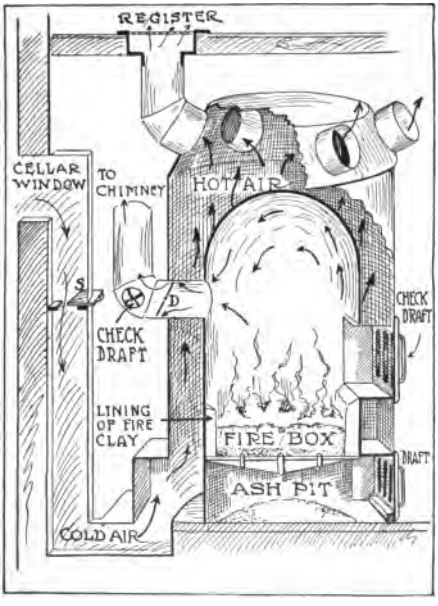
which comes from coal, to escape up the chimney. The hottest fire is obtained when the damper and draft are both open and the check draft closed, as this allows a free passage of air through the burning coal. By opening the check draft, closing the draft, and partially closing the damper, the fire will burn slowly. By closing the damper completely, the air current is checked and burning almost stops. If the room is overheated, close the draft, open the damper and the upper door of the stove. The air from the room will then rush in over the coal and pass up the chimney, thus cooling the stove without helping the materials to burn. In checking the fire, always close the draft. If the draft is left open and the damper closed, the poisonous gas, carbon monoxide, may escape into the room. A very small percentage of this gas in the air is fatal. Carbon monoxide has no odor to warn of its presence and people have been suffocated while sleeping in a room with a stove in which the fire was checked incorrectly.



Convection currents caused by a hot stove.

How a room is warmed. — In the case of the old-fashioned fireplace, although it is still used because of its coziness and good cheer, very little heat is given to distant parts of the room, most of the heat going up the chimney. The stove transfers to the room by convection and radiation about seventy to eighty per cent

of the heat obtained from the fuel. Air coming in contact with the hot surface of the stove expands and becomes lighter, and is pushed up by heavier air, which comes in to take its place (see arrows in diagram). These warm currents of air become cool as they pass by the windows and cold walls and other surfaces which absorb heat, and sink again to the floor. Since the stove is warmer than other objects in the room, it radiates heat to them; heat is brought also through the metal from the inside to the outside surface by conduction. Thus all three methods of heat transference are used to some extent in heating a room.



A hot-air furnace.

The hot-air furnace. — The hot-air furnace has come into general use and is much liked because it does the work of several stoves and requires no more attention than one. The furnace is simply a large central stove placed in the cellar, and covered with a metal jacket, from the top of which metal tubes, or ducts, lead out to the different rooms to be heated. Air from out of doors is brought to the bottom of the space between the fire box and the inclosing jacket,

and as it becomes hot, rises and passes through the pipes to the various rooms. A study of the diagram on page 192 shows that nearly the same method of heat transfer takes place in the furnace as in the case of the stove.

Regulation of the air supply. — It is well to remember that air when heated increases in volume from five per cent in cool to over twenty per cent in extremely cold weather. For this reason less cold air should be let into the furnace through the cold air flue in very cold weather. The small slide used to regulate this volume of air (see *S* in diagram) should be adjusted according to the weather outside, otherwise much coal may be wasted in order to keep the rooms warm. Some houses have a system by which the warm air after circulating through the rooms is sent to the furnace to be warmed again. This is more economical of heat, but does not give as good ventilation.

Advantages and disadvantages of the hot-air furnace. — The hot-air furnace is less expensive to install than either steam or hot water, is easily operated, and gives up heat quickly. The disadvantages of a furnace in a large residence are that the long horizontal pipes do not take heat to the distant rooms leading against the force of the wind. The hot-air furnace heats irregularly, and is unsatisfactory on days when there is a strong wind, and after it becomes old gives off much dust and some gas into the house.

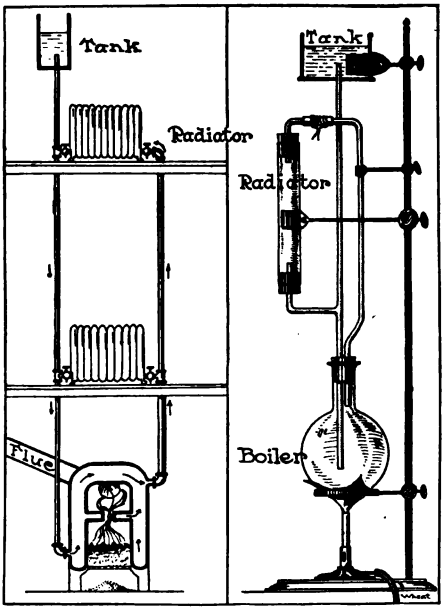
Experiment. — To show the principle of hot-water heating.

Materials: Apparatus shown in diagram.

Method: Fill the apparatus with water. This can be done by pouring water into the tank at the top and opening the clamp at the top of the bent tube until water fills both tubes. Close the clamp. Drop two or three crystals of potassium permanganate through the rubber tube

into the glass tube, connect the tubes and fill the tank partly full of water. Open the clamp. Heat the flask.

Observation and Explanation: Notice all changes. Describe everything that happens. Explain what parts of a hot-water heating system are represented by the different parts of the apparatus.



Hot-water heating system at the left, and apparatus to illustrate it at the right.

The hot-water heating system. — In the hot-water heating system, we have a combined furnace and boiler in the cellar, radiators in the rooms, connecting pipes to bring the water to the radiators and back to the boiler, and a tank known as the *expansion tank* at the top of the house, in which the water may rise as it expands. The principle of heat transfer from the boilers to the radiators is that of convection. The water in the boiler is never heated to the boiling temperature. It enters the radiators at a temperature of 175 to 185 degrees Fahrenheit, and leaves it ten degrees colder. This difference in temperature causes the water to grow heavier, and is responsible for the flow through the pipes.

How a room is warmed by hot water. — As soon as the hot water reaches the radiator, heat is conducted through

the metal to the outside surfaces. Air coming in contact with the radiators is heated, and this heat is given to other objects in the room by convection, while some heat is radiated directly to the walls and objects in the room. Thus the room is heated by convection more than by radiation, and we have a more even distribution of heat than by stove or by steam. One drawback to the hot-water system is the fact that in the sleeping rooms we cannot cut off the heat without danger of freezing the water in the radiator. The best plan for those who like to sleep with the windows open is to cover the radiator at night with a heavy blanket or some good non-conducting substance.

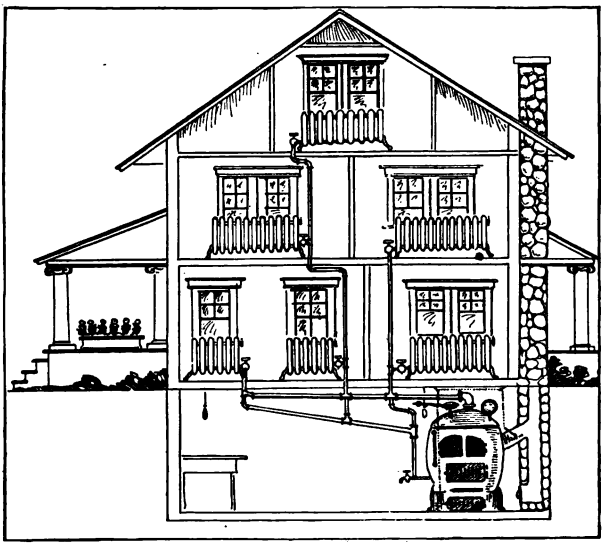
Advantages and disadvantages of hot water. — This is one of the most expensive systems to install, but it is more economical to operate than the hot-air furnace or the stove. With it the rooms may be kept at an even temperature, but unfortunately, if the water gets cold it takes a long time to warm it up. As the system provides no ventilation, we must secure fresh air in some other way. An excellent system is the combination of hot water and hot air, in which the boiler is situated in the top of the furnace, and the water thus heated is passed to rooms far distant from the furnace.

Steam heat in the home. — In the steam-heating systems, the parts are practically the same as in the hot-water system, except that there is no expansion tank and the pipes are closed throughout. Steam made by boiling water passes through the pipes to the radiators. In the radiators the steam condenses, giving off its load of heat. The water formed by this condensation leaves the radiator and is brought back to the furnace again, either by a system

of return pipes, or if the house is small, it may return through the steam pipe.

Experiment. — To show the great amount of heat stored in steam.

Materials: Calorimeter (a soup can will do). Flask. One-hole stopper and tube. Rubber tubing. Steam trap. Thermometer. Ring stand. Burner.



Steam-heating system.

Method and Observation: (*a*) Weigh the calorimeter half full of cold water. Record the temperature. Boil the water in the flask. Connect the steam trap and when the water is boiling put the free end of the trap into the cold water. Let it run for about five minutes. Remove the trap. Stir well, and take the temperature. Weigh. What has caused this increase in weight? How many degrees in temperature was the water warmed by the steam? (*b*) Fill the calorimeter again with the same quantity of cold water used in (*a*), and at the same temperature. Pour into it a quantity of boiling water equal in weight to that of the steam added in (*a*). What is the rise in temperature?

Conclusion: Which will give the larger quantity of heat, a given weight of water at the boiling point, or the same weight of steam at the same temperature? Which is hotter, steam or boiling water? If you are not sure, make a test.

Advantages and disadvantages of steam heating. — Although less coal is used in steam heating than in most other systems, no ventilation is supplied and an uneven temperature is produced, the room sometimes being very hot and sometimes very cold. One needs to be quite an engineer to run this system properly. The snapping or pounding in the steam pipes is caused by what is known as a water hammer, which is produced by the water suddenly rushing into a vacuum, and striking the pipe or the other water there a hard blow. When steam in the steam-heating system suddenly comes in contact with the cold radiator, it condenses, and a vacuum is produced. If there is water in the pipes with pressure behind it, that is, steam coming from the boiler, it may be sent through this vacuum with great speed, and made to strike a hard blow against the metal pipes. The remedy is to admit steam slowly when first warming up the cold system. Steam, like hot water, has an advantage over the hot-air system in that it carries no dust. Because of the high temperature of the radiators, they need to be only about two thirds of the size of hot water radiators. Steam is used with good results in warming large buildings.

Protection against loss of heat. — Much heat is often lost through the radiation from pipes in the cellar. A good plan is to have these pipes covered with some insulating substance, so that the heat will be retained and delivered where it is needed. Much leakage of cold air is often found around windows and doors. If the window

rattles, you can be sure that cold air is leaking into the house. One way to prevent this is by placing weather strips along on the outside of the window where it fits into the sash. A much better method of keeping out cold air is by means of the double window. Ventilation may be obtained through a loose pane on hinges which can be opened when desired. The storm door, which is nothing more than a double door sometimes arranged with a tiny antechamber in which one may wait while the inner door is being opened, is another means of keeping out much cold air, especially where there are high winds.

The use of heat in cooking. — In the coal range we have the same principle as the coal stove, except that on one side of the fire box there is an oven separated from the outside walls of the stove by a space. Heat is circulated through this space to warm the oven. A knowledge of the drafts and dampers is necessary in order to heat the oven properly. The main air supply enters through a draft into the ash pit under the coal, passes through the layer of hot coal, helps it to burn, and the hot gases coming from the burning coal pass around the oven and escape up the stove pipe. (See p. 190.) The oven damper, if raised, causes these gases to pass around the oven before entering the stove pipe. When the oven damper is down, the hot gases pass directly out. What would you do to cool the oven?

The oven temperature. — We can control the oven temperature by regulating the size of the fire, by the use of the oven damper, and by opening the oven door. We must remember that some things, such as roast meats, require a high temperature, while custard requires a much lower temperature. The accompanying table shows some of the differences in temperature for cooking different foods.

OVEN TEMPERATURES FOR BAKING VARIOUS FOODS

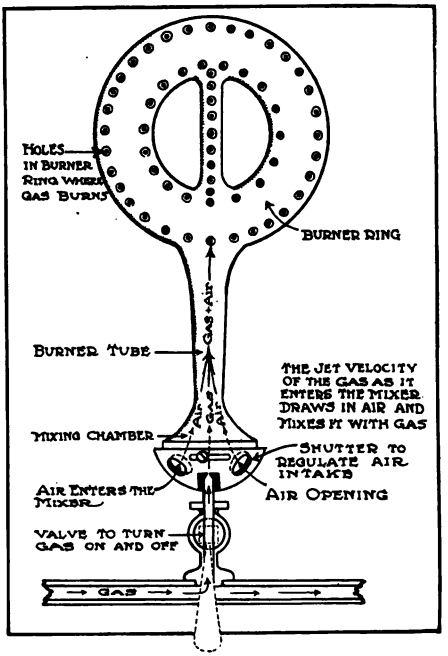
Searing Roasts	500° F	Bread	350° F
Biscuit	450°	Layer Cake	300°
Pies	400°	Custard	250°

Experiment. — How to produce a luminous and a non-luminous gas flame.

Materials: Bunsen burner. Chalk dust.

Method and Observations: Close the air holes near the base of the burner. Light the gas. Describe the flame. Open the air holes. What change in flame occurs? When you have a clear non-luminous flame, blow a little chalk dust into the air holes. Effect on the flame? Place a piece of heavy white paper down over the luminous flame for an instant. What is the product?

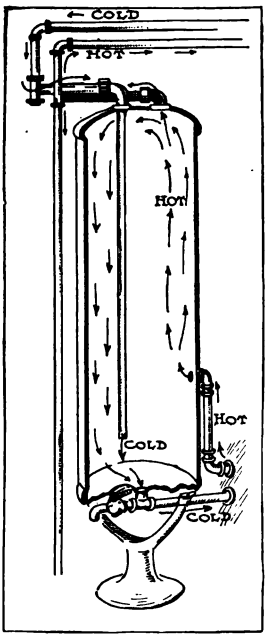
Conclusion: From these results try to give a reason why the gas flame is luminous when no air is mixed with it. What is the part that carbon plays in a luminous flame? What type of burner is best for cooking devices?



Top burner of the gas range.

The gas range. In many homes where gas is available, the gas range has supplanted the coal or wood stove for cooking. It is not only quicker, cleaner, and more convenient, but, especially if natural gas is available, it is much cheaper.

The top burners have a tube at the base, in which are openings for the entrance of air. The air mixes with gas entering the tube, and the mixed gases are passed through small holes in the burner ring, and burned. This burning should take place with a blue flame. If too little air is admitted, the flame will be yellow, and soot will collect on the cooking utensils. The burner should be kept clean, for dirt clogging the air mixer will cause smoke. The burner can be taken off and boiled in water containing washing soda, and small particles of dirt removed by picking out with a fine needle or wire. When lighting the oven one should be careful first to open the oven door, light the pilot flame, and then turn on the gas. A gas stove should have a stove pipe to carry off the gases into the chimney flue.

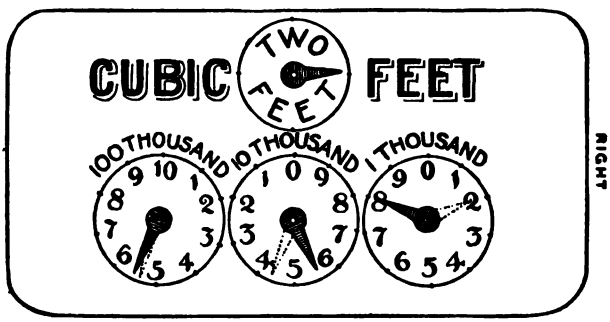


Hot-water supply.

The hot-water supply. — Hot water has become almost a necessity in houses, in the country as well as in the city. The hot-water supply for household purposes is obtained by the use of the hot-water storage tank connected to the coal range or independent heater. In the range the water is heated by means of a pipe passing close to the fire box, and then running to the boiler. In addition a gas stack is often attached to the tank. In this the gas flame heats a coil containing cold water, the rapidly heated

water rises as it becomes lighter, and passes into the pipe of the hot-water tank. When the hot water is drawn from the faucet, a supply of cold water enters through the pipe which enters at the top of the tank and extends down to a level just above the top of the heating device. In the instantaneous gas heater, the gas is automatically turned on and lighted by a pilot flame when the faucet is opened. The water is heated as it passes through the coiled pipes in the flame.

Reading the gas meter. — Since gas is a commodity which is delivered to our homes, we should learn to read the meters,



Recording dials of gas meter.

so as to be able to know how much gas is burned, and whether we use it economically. The recording device of a small gas meter has three small dials, and a fourth one still smaller on top, which has a scale registering two cubic feet. Above the three dials are marked the figures 100,000, 10,000, and 1,000, and the face of each dial is figured from 0 to 9. When the gas passes through the meter, the hands revolve, the two outer ones in the direction of the hands of a clock, and the inner one in the opposite direction. In the illustration the 100,000 dial hand is between 5 and 6, the 10,000 between 5 and 6, and the 1,000 at 8. This means

that the meter stands at 55800 cubic feet. The last time the meter was read, as the dotted position of the hands shows, it stood at 54200. Another kind of meter is so arranged that a certain amount of gas is given out after placing a coin in a slot in the meter. When this gas is exhausted, the meter automatically cuts off the supply until another coin is dropped in. One may easily check up the amount of gas which can be used before the supply is cut off by reading the special index controlled by the coins inserted.

Other fuels used in the home. — Many people who do not live where gas is piped into the house, use the blue flame kerosene or gasoline stoves. In these stoves the fuel flows from a reservoir down to a wick in the burner, where, as the metal becomes heated, the fuel evaporates, mixes with air and burns in the same manner as does the gas in the gas stove. In practically all stoves using kerosene or gasoline the blue flame is produced in this way. Alcohol is sometimes used as a fuel where a hot flame is needed for a short time, as with the chafing dish, and most of us have used "solidified alcohol" which now comes in convenient tins for use at any time. In this form of fuel the alcohol is absorbed in a soft wax or paraffin. It must be kept from the air, however, or it will lose the burning properties quickly through evaporation.

SCORE CARD. HEAT IN MY HOME

	Excellent	Fair	Very Poor	My Score	
					Total
WARMTH	All parts of home warm enough in coldest weather (5) All parts of each room can be evenly heated (5)	Some rooms not warm enough in coldest weather (4) Some rooms evenly heated; others not (3)	Temperature in *all* rooms too cold in coldest weather (0) Unequal heating in all rooms, none comfortable in every part (0)	....	....

SCORE CARD. HEAT IN MY HOME — *Continued*

	Excellent	Fair	Very Poor	My Score	Total
VENTILATION AND PROTECTION AGAINST LOSS OF HEAT	Large supply of fresh air circulated in rooms (2)	Small supply of air circulated in rooms (1)	No air in heating circulation (0)	....	
	All pipes and furnace protected against loss of heat (2)	Pipes but not furnace protected against heat loss (1)	No protection of pipes or furnace (0)	....	
	Weather strips, storm doors, and storm windows new and tight ventilation sashes in windows (6)	Weather strips old, storm doors leaky, storm windows without ventilation sashes (3)	No weather strips, storm doors, or sashes. Windows rattle in wind and leak air (0)	....	....
ECONOMY OF FUEL	Fuels (except gas) purchased in large quantities at one time (4)	Fuels purchased in small quantities as: 1 gal. oil; ¼ ton coal (2)	Very small quantities purchased as: 1 qt. oil; 1 bag coal; 1 bu. wood (0)	....	
	Wood, coal, coke, or natural gas used in kitchen in winter (2)	Artificial gas used sometimes when have coal or wood fire (1)	No saving attempted by using cheaper fuels (0)	....	
	Fuel not wasted in ashes or more gas burned than needed (2)	Fuel often saved by attention to gas burner and ash sifting (1)	No attention paid to economical use of gas or to ashes (0)	....	
	Electric heat seldom used (2)	Electric heat often used (1)	Electric heat commonly used (0)	....	....
ECONOMY IN TIME AND WORK DONE	No extra dust in winter (3)	Little extra dust in winter (1)	Much extra dust in winter (0)	....	
	No ashes (electricity or gas) (3)	Little ash or clinker (2)	Much ash or clinker (0)	....	
	Not more than 15 min. required per day for proper care of heating devices (2)	Not more than 30 min. required for care of heating devices (1)	More than 30 min. a day required for care of heating devices (0)	....	
	Thermostats and other heat regulating apparatus so that furnace can be regulated without going to cellar (2)	Lacks either thermostats or heat regulating apparatus (1)	No thermostats or heat regulating apparatus (0)	....	....
COOKING	Cooking stove makes no dust or dirt (electricity) (2)	Cooking stove makes little dust or dirt (gas, kerosene) (1)	Cooking stove makes much dust or dirt (wood, coal) (½)	....	
	Stove safe (2)	Stove moderately safe (1)	Stove not safe (0)	....	
	Stove easy to manage (3)	Stove moderately easy to manage (2)	Stove difficult to manage (0)	....	
	Cooks and bakes well (3)	Cooks well; bakes poorly (1)	Cooks and bakes poorly (0)	....	....
GRAND TOTAL					

REFERENCE BOOKS

Barber, *General Science*, Chapter II. Henry Holt and Company.
Burns, *Story of Great Inventions*. Harper and Brothers.
Butler, *Household Physics*, Chapters on Heat, pages 6–57. Whitcomb and Barrows.
Caldwell and Eikenberry, *General Science*. Ginn and Company.
Clark, *An Introduction to Science*, Chapters I, II, III. American Book Company.
Hopkins, *Experimental Science* (For help in projects). Munn and Company.
Lunt, *An Illuminating Gas Project*. General Science Quarterly, May, 1917.
Lynde, *Physics of the Household*, Chapters VII, XI. The Macmillan Company.
Mowry, *American Inventions and Inventors*. Silver, Burdett and Company.
Smith and Jewett, *Introduction to the Study of Science*, Chapter II. The Macmillan Company.
Walrath, *Hot Water Boiler Demonstration*. General Science Quarterly, Jan., 1918.
Williams, *How It Works*, pages 386–391. Nelson Company.
Williams, *Introductory Fire Lesson*. General Science Quarterly, May, 1917.

CHAPTER XIII

FIRE PREVENTION IN THE HOME

Problems. — 1. *To learn the estimated fire loss in the United States.*

2. *To discover the usual sources of fires.*

3. *To understand why "fire prevention" is so important.*

4. *To learn the principles underlying the putting out of fires.*

5. *To see how home fire extinguishers are constructed and used.*

Experiments. — 1. To show how spontaneous combustion takes place.

2. To show how to extinguish
   (*a*) Burning fat.
   (*b*) Gasoline.

Project I. — TO REMOVE THE FIRE HAZARDS FROM MY HOME.

1. This requires a good knowledge of fire dangers and the most common sources of fires.

2. Thorough study of the home with reference to the possibility of fire should be made.

3. Fire dangers must be removed by appropriate methods.

4. A complete report will include a discussion of:
   a. Principles.
   b. Conditions found.
   c. Changes made.

Suggested Project. TO MAKE A TOY CHEMICAL FIRE EXTINGUISHER.

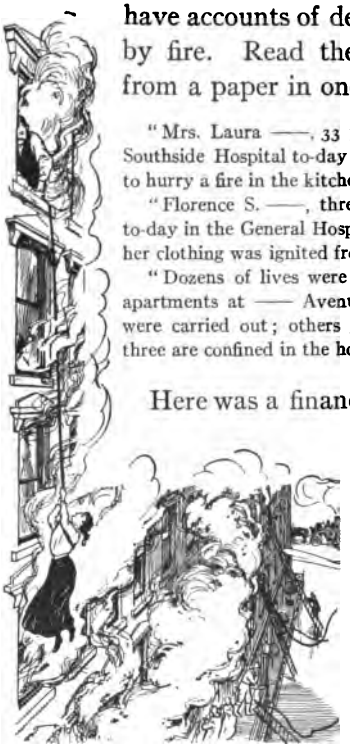
Fire and its dangers. — You may have been fortunate enough never to have lost your home or loved ones through fire, but nevertheless that danger is always with us. It stands ready for the careless moment when you give it an opportunity to burst forth with its suffocating and deadly flames, and many are its victims. Every week the papers have accounts of destruction and suffering caused by fire. Read the following clippings selected from a paper in one week:

"Mrs. Laura ——, 33 years old, of 66 —— Street, died in the Southside Hospital to-day from burns suffered when she attempted to hurry a fire in the kitchen stove by pouring oil over it."

"Florence S. ——, three years old, of —— Avenue, died early to-day in the General Hospital from burns received yesterday, when her clothing was ignited from a firecracker."

"Dozens of lives were imperiled in a fire which destroyed the apartments at —— Avenue early this morning. Some occupants were carried out; others jumped from the second story window; three are confined in the hospital. The damage was $4000."

Here was a financial loss great enough to have bought each one of you in the class two bicycles, a pair of skates, skis, and a good sled.



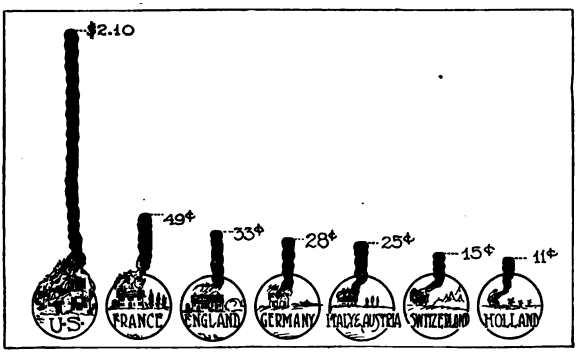
A thrilling rescue, but the fire was unnecessary. (After Richman.)

"Fire which threatened to wipe out a big section of Homestead caused damage of upwards of $45,000. High winds carried sparks and several other fires were started. Fires were only extinguished after aid arrived from surrounding boroughs."

The money loss in this fire would have bought each one of the pupils in your class an automobile. If reports of fires which have occurred in the entire United States in the last twenty-four hours could be laid on your desk

you would have a collection of about fifteen hundred. Records of past years show that the number of fires averages about fifteen hundred a day; one every minute.

Enormous fire losses. — The fire loss in the United States for 1919 was $325,000,000. There were in the United States during 1919 over 5,000,000 fires. Suppose these fires spread at equal intervals of time, and the



Relative per capita fire losses in different countries.

fire loss was distributed evenly throughout the year, then,

Every second $10.00 in property is destroyed.

Every minute a new fire starts somewhere in the United States.

Every hour two lives are lost and seven persons are injured through fire.

Every day enough property value is destroyed by fire to feed and clothe a city of 50,000 people for ten days.

Every week the fire loss is enough to build 100 miles of good macadam road.

Every month the loss from fire is equivalent to a sum of money which would buy the grounds, erect the buildings,

and provide an endowment to pay the running expenses of a large college.

In a year, the money value of fire losses would pay salaries, books, and supplies for all public education in the entire United States for more than half a year.

Charles W. Baker, in an address entitled "A Street of Desolation," said in speaking of the damage done in a single year that "the buildings consumed, if placed on lots of 65 feet frontage, would line both sides of a street extending from New York to Chicago. A person journeying along this street of desolation would pass in every thousand feet a ruin from which an injured person was taken. At every three quarters of a mile in this journey he would encounter the charred remains of a human being who had been burned to death."

Why are there so many fires? — Are these losses by fire necessary? What causes the fires? Many fires are reported as "cause unknown," but a study of the causes in a large number of other cases shows that the principal cause of fires is CARELESSNESS. No one of us can truthfully say that he has not been careless about such matters. It is time that we begin a new era of thoughtful, careful attention to the ways and means of safeguarding the home, the business houses, and the factories against fire.

Sources of fires in the home. — The cause of about 90% of the fires is carelessness in regard to a few things about the home. Some of the most important things about which we ought to be more careful are:

a. The use of kerosene and gasoline.

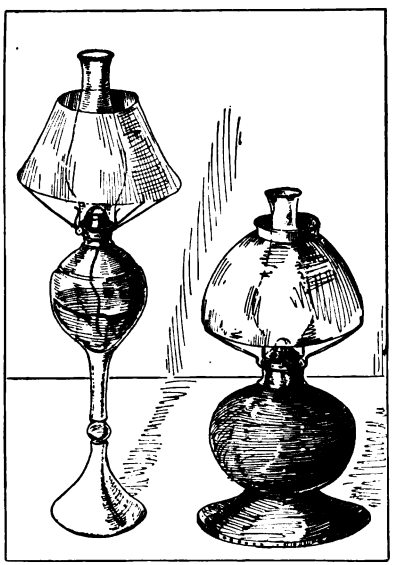
b. Matches and all uncovered flames.

c. The heating plant, stove pipes, and chimney.

d. Electrical devices and wiring.

e. Oily rags and other rubbish.

Matches. — In the United States half a million flames are produced with matches on an average every minute. Every bare flame has the possibilities of serious consequences. Our chief concern in the house as regards matches is to keep them away from children who are too young to realize the danger, and from rats and mice, which are known at times to cause fires by gnawing the match heads. Nearness to heated pipes or flues at times ignites matches. Protection against animals is secured by inclosing in a covered metal or earthenware box. This will also smother the flame quickly if set on fire from a near-by source of heat. Placing on a high shelf or in a locked closet or drawer is usually sufficient protection against the small child.



Which lamp is the greater fire hazard?

Flames for light. — The candle, kerosene lamp, and gas flame are common sources of danger in the home. The candlestick and lamp should have a low center of gravity and a broad base to guard against tipping over. Unprotected paper or cloth shades for candles are extremely dangerous. A mica chimney should separate the flame from the shade.

The danger from lamps comes largely from leaving them for a time, from dropping them when carrying them about, and from filling them when lighted. Never leave a burning lamp in a room by itself for any length of time. Use only lamps with metal reservoirs. Always fill lamps by daylight. Keep the lamp always in good order. Observation of these simple rules will do much to prevent serious fires.

Fire dangers from heating devices. — Disastrous fires from chimneys, stoves, furnaces, and portable heaters are common. Perhaps most deaths from burning come from kindling fires in the stove. Match heads or lighted kindlings set the clothing on fire. Scarcely a week goes by that you cannot find in the papers an account that some one who used kerosene to kindle the fire was seriously, if not fatally, burned. Kerosene burns so easily it is never safe to use it for starting a fire. Hot stovepipes, the heater itself, or hot air ducts, if close to woodwork, are fire hazards. Ashes are never safe when left loose on the cellar floor, or in wooden receptacles. Metal containers are the only safe ones.

She had used kerosene oil to start her fire 432 times without harm. The picture shows what happened on the 433d time.

Miscellaneous sources of fire. — All celluloid articles contain oxygen necessary for combustion within them-

selves. On this account celluloid burns quickly and cannot be extinguished by smothering. Hot air from a register will sometimes ignite celluloid. Make a list of celluloid articles in your home.

Spontaneous combustion is a frequent cause of disastrous fires. Certain oils, as linseed oil used by painters, absorb oxygen in drying. By this process heat is generated. If the oil is on poor heat conducting materials, as rags and cotton waste, the heat may increase enough to reach the kindling point of the materials and fire results. This usually happens when nobody is around and so the fire makes good headway before it is discovered.

Experiment. — To show how spontaneous combustion takes place.

Materials: Carbon disulphide. Phosphorus. Test tubes. Filter paper. Ring stand.

Method: Dissolve a piece of phosphorus the size of a pea in half a test tube of carbon disulphide.

(*Note:* Do not handle phosphorus with bare fingers. Phosphorus and carbon disulphide are both inflammable.) Wet the filter paper with this solution by rolling it up and inserting it into the test tube. Open the paper and expose it to the air on a ring stand. As the carbon disulphide evaporates the phosphorus oxidizes and generates heat.

Observation and Conclusion: What happens? Was heat generated faster than it could be carried off? Explain just how the fire occurred.

Burning fat or oils used for frying on the stove are not serious dangers as they can be smothered easily with a cover or a heavy rug. Trying to carry the burning fat to the sink is dangerous. A few drops spilled may set fire to other things. The addition of water will scatter the burning drops and spread the fire.

Gasoline is treacherous. — It is a safe rule never to clean with gasoline indoors, and never keep gasoline in a glass bottle. There are other liquids easily obtainable which

will not burn, but which will clean just as well as gasoline. These can be bought at the drug store. They are safe. Use them.

Extinguishing fires. — Since a fire requires oxygen, fuel, and a temperature above the kindling point, if you deprive a fire of any one of these three, it will be extinguished. There are, then, three possible ways to put out a fire: by smothering, by removing the fuel, and by cooling.

Smothering. —Smothering is the process of keeping oxygen of the air away from the burning substance. With the exception of a few substances smothering is an effective way of extinguishing a small fire. A woolen blanket, rug, or coat is better than one made of cotton because it is less inflammable. The blanket is much more effective wet than dry, but it may be used dry. Another way to smother a flame is by setting free a non-combustible gas about the flame which will push the air away and extinguish the fire. This is sometimes done with the following chemicals: carbon dioxide, ammonia, carbon tetrachloride, and water in the form of steam. Substances like celluloid, and explosives which contain sufficient oxygen for combustion, cannot be extinguished in this way.

Removing fuel. — It is often possible to remove the combustible material from the vicinity of the flame and thus extinguish it in a short time. Covering combustible material by banking with sand and trenching to remove fuel are practiced in brush and grass fires. Back firing in forest fires utilizes the principle of fuel removal, as does the dynamiting of buildings in the path of the fire in a large city conflagration.

Cooling. — Water is the most universal fire extinguisher. It has many properties which favor its use. It can be thrown long distances in a steady stream. It is non-combustible. One pound of it has greater cooling effect than the same weight of any other sub-

Water, our best fire extinguisher.

stance. On changing to steam it increases 1700 times in volume. The change from liquid to steam absorbs a large amount of heat, thus adding to its value as a cooling agent. The steam also tends to smother the fire by excluding air.

The hand chemical extinguishers. — The carbon tetrachloride and the carbon dioxide extinguishers are two types

of chemical extinguishers suitable for use in the house, the school, and the shop when the fire is small.

Experiment. — How to extinguish (a) burning fat; (b) burning gasoline.

Materials: Lard. Gasoline. Evaporating dish. Ring stand. Heavy cloth. Carbon tetrachloride. Test tubes.

Method and Results: (*a*) Heat a teaspoonful of lard in an evaporating dish. When smoking hot let two or three drops of water fall into it. Would water be a good substance to extinguish burning fat? Wet the cloth and carefully lay it over a dish of burning fat, excluding all air.

(*b*) Pour a tablespoonful of gasoline into the small evaporating dish. Set it on fire. Pour water from the test tube into it. Is the fire extinguished? Smother with a cloth. Pour this out and use another tablespoonful of gasoline. Set it on fire. Pour carbon tetrachloride into it from a test tube. Result?

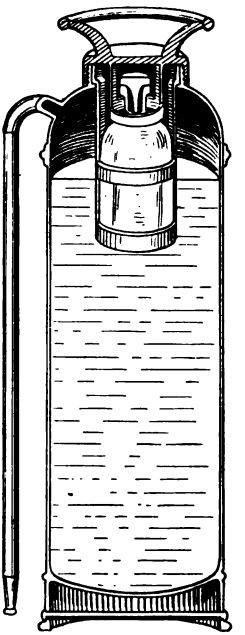
(*Note:* Carbon tetrachloride is non-inflammable and evaporates as easily as gasoline.)

Conclusion: What advice would you give for extinguishing burning fats and gasoline?

The carbon tetrachloride extinguisher holds about a pint of volatile liquid in a small container to which a force pump is attached. When the container is opened and the pump worked, a stream of liquid may be thrown upon a near-by blaze. The liquid changes to gas, which smothers the flame. When this extinguisher is used take care not to breath the fumes given off for they are harmful and in a number of instances have proved fatal. This type of extinguisher is particularly valuable for extinguishing small gasoline and oil fires. Water cannot be used for these fires since the oil or gasoline would rise to the surface of the water and continue to burn.

The small carbon dioxide extinguisher holds $2\frac{1}{2}$ gallons of water, in which are dissolved $1\frac{1}{2}$ pounds of baking soda and a bottle containing 4 oz. of strong sulphuric acid is suspended above the solution. When the extinguisher

is inverted, the acid mixes with the soda and produces carbon dioxide gas. The gas is confined and creates such great pressure that the liquid is forced out the hose to a distance of 40 to 50 feet. The water which escapes is charged with carbon dioxide and has some soda in it. All these substances are good fire extinguishers. The flow of liquid may be stopped at any instant by inverting the extinguisher. But after once inverting, it must be recharged at once. This is the kind of extinguisher for the house, since the suffocating gas is less than in case of the volatile gas extinguisher which is used in the garage.



Section of a carbon dioxide extinguisher.

Safety first. — If you get caught in a burning building and the fire has made such headway as to be a serious menace to you, it is your first duty to save your life. It is well to be prepared for any emergency and to know in advance just what to do. Do you know where the stairs are? The fire escapes? If it is necessary to pass through a smoke-filled room, tie a wet cloth over the nose and mouth to absorb the smoke and crawl on the floor as there is less smoke near the floor. If you think you must jump from a window, throw out pillows, cushions, and mattress to land on and jump only if forced to it. Bed clothing may be tied into a rope on which to climb to safety. Above all *keep cool.*

Scoring fire hazards. — Score your fire hazards rigidly and then go carefully over your list to see what changes you can make *at once* to improve conditions. If the matter is outside your own control talk it over with other people and get their advice as to how best to do away with the hazard. We should all work together to prevent unnecessary fires. A rather different score card could be made by boys and girls living in small rural communities or in farming or lumbering sections. If you live under such conditions try to make a score card to fit your conditions.

The best air in a burning house is near the floor.

THOUGHT QUESTIONS

1. Suppose you were visiting and were awakened in the night by the cry of "Fire" and could smell the smoke. What are some of the different conditions you ought to be able to meet? Tell just what you would do under these different conditions.

2. How is it that "fireproof" buildings are sometimes destroyed by fire?

3. Prepare to debate one side of this question. Resolved: That the use of kerosene in the home is a greater fire hazard than the use of gas.

4. Make out a set of rules needed in your home to remove some of the present fire risk practices.

5. Give as many reasons as you can why, considering all the harm fire does, the world is better off with it than it would be without it.

6. Plan a "fire drill" for the home. Assign a particular thing for each member of the family to do, as: giving the alarm, trying to extinguish the fire, saving things of value. Try it out by giving the alarm unexpectedly.

SCORE CARD. FIRE-HAZARD SURVEY OF MY HOUSE

		Score		
			Perfect	Allowed
1.	Fireproof constructions			
	Slate or other fireproof roof	2½		
	Stone, brick, or concrete walls . . .	2½	5	
2.	Not nearer than 25 ft. to other wooden buildings		5	
3.	Metal ash cans used	2½		
	Gas connections of metal pipe, not of rubber	2½	5	
4.	Matches			
	Safety matches used	2½		
	Out of reach of children	2½	5	
5.	(*a*) No swinging gas jets or lamp brackets near curtains.			
	(*b*) Oil lamps of metal, low, not easily upset (5). Score *either* (*a*) or (*b*) . .		5	
6.	No one in family is careless with fire . .	2½		
	No smokers in family	2½	5	
7.	No stove pipe through wall or floor . .	2		
	No stove within one foot of unprotected wall	1½		
	Metal or asbestos mat under stove and extending 10 in. in front	1½	5	
8.	No gasoline kept in glass bottle	1½		
	No gasoline used for cleaning indoors . .	1½		
	Kerosene never used in kindling fire . .	2	5	
9.	No rubbish allowed to collect	2		
	No oily rags collect or left	1½		
	No celluloid articles in house	1½	5	
10.	Have a hand fire extinguisher	2		
	Fire engine house within ¼ mile	2		
	Hydrant within 300 ft. of house	½		
	Fire alarm box within 500 ft. or have a telephone	½	5	
	Total		50	

REFERENCE BOOKS

Adams, *Harper's Outdoor Book*, pages 191–200 (Fire engines). Harper and Brothers.

Circular 75. Safety for the Household, U. S. Bureau of Standards: good account of fire hazards and treatment of injured.

Croker, *Fighting Fire*. Dodd, Mead and Company.

Hill, *Fighting a Fire*. The Century Company.

Moffett, *Careers of Danger and Daring*, pages 209–256 (Life of firemen). The Century Company.

Report U. S. G. S. for 1909: data and comparisons on the amount of fire damage done in the U. S.

Reports from State Fire Marshal: in most states.

Richman and Wallach, *Good Citizenship*. American Book Company.

Safeguarding the Home against Fire: A pamphlet, 91 pp. By National Board of Fire Underwriters: very complete account of causes of fires, how to guard against them, and what to do in emergencies.

Warren, *Stories from English History*, pages 303–307 (Great fires). D. C. Heath and Company.

Weeks, *Avoidance of Fires*. D. C. Heath and Company.

Whitman, *Fire Hazards and Safeguards: Ten Lessons*. General Science Quarterly. March, 1920.

CHAPTER XIV

CLOTHING AND ITS USES

Problems. — 1. *To understand how the temperature of the body is regulated.*

2. *To learn what is proper clothing for our bodies and feet.*

3. *To see of what our clothes are made.*

4. *How can we detect fraudulent materials in clothing?*

5. *To see how clothing is cleaned.*

Experiments. — 1. To distinguish wool from cotton by the burning test.

2. To show the effect of chemical reagents on different fibers.

3. Removal of spots and stains.

Project I. — TO FIND OUT OF WHAT MATERIALS CLOTHES ARE MADE.

1. Find out how to make various chemical tests for different kinds of fibers.

2. Find out some of the characteristic physical properties, including examination under the microscope if possible.

3. Practice in applying tests to poor materials.

4. Practice in applying tests to known mixtures.

5. Use of tests in determination of mixed goods, or for adulteration, filling, etc.

6. Common fibers for testing: cotton, mercerized cotton, linen, wool, silk, artificial silk.

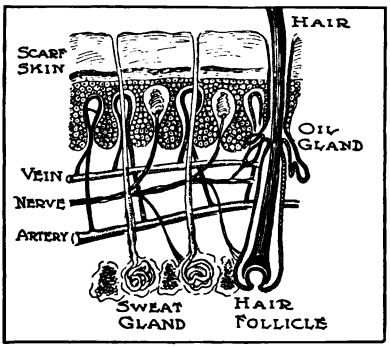
7. Apply tests to determine composition of various articles of clothing worn, if samples for testing can be obtained.

8. Your report: Make diagrams of fibers seen under microscope.
   Give an account of all testing work.
   Mount specimens of original and tested cloth.
   Conclusion regarding adulteration.

Suggested Projects.

1. TO PREPARE A TABLE TO SHOW HOW TO REMOVE SPOTS AND STAINS FROM DIFFERENT KINDS OF CLOTH.
2. TO MAKE SOAP FROM HOUSEHOLD GREASE.

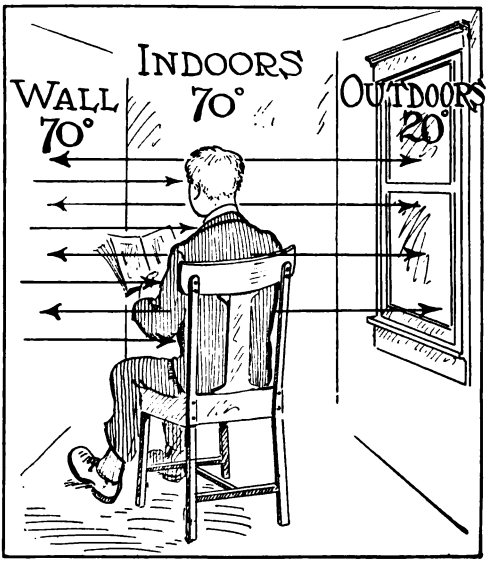
The skin regulates our body temperature. — We are all aware of the fact that sometimes we feel hot or feel cold, but if we were to take the body temperature at either of these times, we would find it varied little from its normal heat of 98.6 degrees. To be sure, the outer part of the skin would be colder on a cold day and warmer on a warm day, but the skin itself has a very complex mechanism for regulating our body temperature. By means of the sweat glands shown in the diagram as little coiled tubes, and the very delicate nervous apparatus which we need not now try to understand, the skin is enabled to regulate the heat of the body. When we do more work and the body becomes warmer from the increased oxidation within it, the skin automatically is enabled to throw off this heat and it is able also to retain more heat on a cold day.



A section through the skin.

How the body loses heat. — Heat is lost from the body by the three methods we have studied in the preceding

chapters. A certain amount of heat is lost by conduction, although the air is a very poor conductor, and warm fabrics get much of their heat-holding qualities because of the stagnant air confined in their meshes. Most of our heat from the body is lost by convection. When we fan ourselves, we create a current of air, causing cooler air to replace the warm air about the body. We also lose heat by radiation to other solid objects which are cold. It is very easy to take cold by sitting on the damp ground, or close to cold windows or walls, because in this way warmth is removed rapidly from one part of the body.

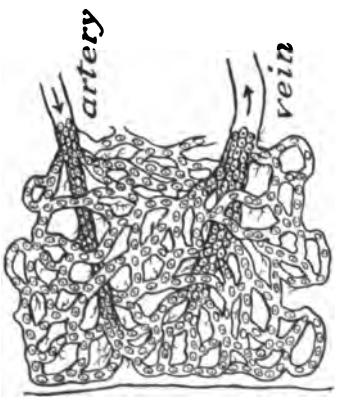


Which side of this boy will lose more heat? Why?

Curiously enough, although we feel warm when we perspire, yet much of the heat of the body is taken away by evaporation of the water from the body surface. On a hot muggy day when the atmosphere about us is moist, little heat is lost by evaporation and we feel much hotter than on an equally hot dry day when we perspire freely. A person may feel the heat far more in New York on a day in August than in the jungles of British Guiana at

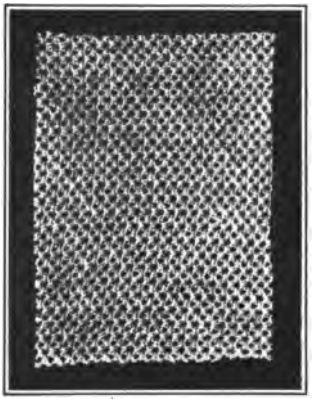
the same time of year, because in the tropics the trade winds cause rapid evaporation of the moisture from the body. On a humid day a blanket of stagnant heated air forms about the body, which makes one feel very uncomfortable. For this reason electric fans and the punkas of India have saved people from much discomfort by keeping the air in motion, thus evaporating the moisture, and removing heat from the body.

Bathing and the skin. — Since the skin is such an important organ for heat regulation and for getting rid of wastes as well, it goes without saying that we should take good care of it. Bathing keeps the pores open and the skin clean. In summer, when perspiration is increased, baths should be more frequent than in winter. A cold shower or plunge every day, both in winter and in summer, is an excellent habit to accustom the skin to different changes. If you find that after a rubdown the skin does not glow and you feel cold and chilly, do not take the baths so cold. It is always well to begin with tepid water and gradually turn on colder as the bath progresses. Hot baths should be taken only at night, as they tend to bring blood to the skin and increase the radiation. When we chill the body, the body resistance is lowered and germs, which are almost always present in our mouths and throats, develop rapidly and cause a cold.



The blood is brought to the surface of the body and there loses some of its heat through the skin.

Underclothes and their uses. — In winter we need underclothes which are non-conductors of heat, and retain the warmth in the body. In summer we need underclothes that do not hold moisture, for wet, clammy underclothes cool us by conduction if it is cold, or if it is warm, make us uncomfortably hot by preventing evaporation, and sometimes even cause a cold to develop. It does not seem to make very much difference what kind of materials are used, whether woolen, cotton, linen, or silk fiber, so long as the underclothes are porous. Woolen underclothes are best for wear in winter, because the natural curly fiber makes them porous, and also because they absorb more water, and this protects the skin from cooling too rapidly in case we get overheated. Most colds are taken because people insist on wearing too much in winter. They wear heavy underclothes and heavy outer clothes, then go from a warm room to the cold outdoors, and back again to warm workrooms where the temperature is often higher than that of summer heat. The better rule is to wear a medium weight underwear in winter and heavier outside clothes, which can be changed as one goes into different temperatures.



Mesh in underwear.

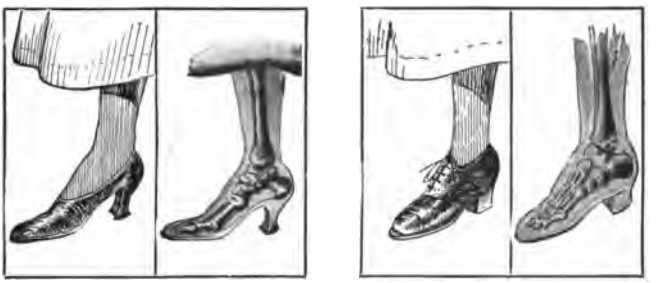
How to wear clothing. — The chief use for clothing is to keep heat in the body, although some people think, as in the case of some animals which wear their fur and feathers for attraction, that "fine feathers make fine

birds." Heat does not easily escape through dry air, and clothing prevents its escape by holding air in little pores of the cloth. Fur of animals, a natural covering, is very warm, yet averages in the case of many animals about 98 per cent air and only two per cent hair. The outer clothes, both of boys and girls, should not be very tight fitting, and not too heavy, especially if heavy underclothing is worn. Tight-fitting clothes interfere with the circulation of the blood and are not hygienic. Clothing should therefore be loose and the weight distributed as nearly equal as possible on all parts of the body. Get the habit of wearing an overcoat, and take it off when you go into the house. Learn to wear different weights of clothes according to the temperature, keeping lightweight and more porous ones for the hot weather. If you get wet, do not sit around in wet clothes.

Care of the feet. — It is very important to remember to keep the feet dry. Wet feet are one of the most common causes of colds. For ordinary wear, heavy-soled shoes may keep the feet fairly dry, but in case of rain, it is better to wear rubbers, although most people consider them a nuisance. Our feet surely should receive our best care, for they bear our body weight the greater part of the working day. They are often harmed in youth by shoes, especially in the case of girls, who pride themselves on the shapely appearance of the feet and ankles. The

A great help in preventing a cold.

high heels worn by many do much to strain the muscles of the feet, and are responsible for many aches and pains in later life, which come as a result of flat feet, broken arches, and other ailments. Corns, callous spots, and blisters are caused by wearing shoes of a wrong size or shape for the feet. Shoes should be long and broad enough to give plenty of room for the toes. They should have a



Notice how the high heel brings the body support in front of the heel, causing an unnatural arching of the bones.

straight last, and the heels should not be too high. A common sense shoe, sold by most dealers now-a-days, is better than the longer, pointed, high-heeled shoe which is fashionable and worn by girls who do not realize the harm caused by wearing a shoe which does not fit the shape of the foot.

Where do our clothes come from? — Most boys and girls would answer this question by saying that their clothing came from the store, but if they stop to think they will realize that animals have a covering of either fur or hide and that man, too, uses these materials for body covering. Long years ago when primitive man lived on the earth, he covered himself with skins which were taken from the animals he killed. To-day we use these same skins, but

after a process of curing and softening they are manufactured into shoes, gloves, and other useful articles. We have gone much further than primitive man in the making of clothes, for we have come to use parts of plants as well as the wool and other materials taken from animals. The cotton plant, linen, from flax, and other fibers such

Sheep are a great asset to the wealth of our nation.

as jute, hemp, ramie, and yucca, as well as that most beautiful fabric of all, silk, which is taken from the cocoon of the silkworm, have all been put to man's best uses.

Wool. — Prehistoric man domesticated sheep because he found he could use them for food and the skins for clothes. Later the wool was carded, spun, and woven by hand. Our woolen materials are woven in factories. The

woolen fibers vary from about an inch to eight or nine inches in length. The long fibers are woven into fine woolen cloths, while the short, coarse ones make some kinds of worsted goods. These fibers are covered with

Plant bearing cotton ready to pick, showing the boll or fruit containing seeds surrounded by cotton fibers. (Museum of Natural History.)

little projecting scales, which cause them to cling together, and this gives the cloth its characteristic woolly or felted appearance and produces a porous fabric which, as we have seen before, holds air and retains heat.

Cotton.—Our Southern states in the past produced most of the cotton used, but to-day cotton is grown in many other warm countries, especially in Egypt. The cotton fiber is really a product of the flower, for as the seeds are formed in the pod, this fiber grows around them as a protection, and consequently the seeds must be removed,

this being done by a process known as ginning. Cotton fibers are smaller than woolen, and under the microscope, have a twisted appearance. This twisting helps in the manufacture of cotton cloth. Cotton fiber contains fewer air spaces than woolen, and therefore cotton cloth is cooler.

Flax grown for fiber.

Experiment. — To distinguish wool from cotton by the "burning test."

Materials: Cotton and wool string. Forceps. Burner.

Method: Set on fire a string of cotton and one of wool at the same time.

Observation and Conclusion: Which burns more rapidly? Which burns with more flame? Observe the odor from each. Tell how to distinguish cotton from wool by the "burning test."

Linen. — Flax, a little plant with a well-known blue flower, produces all of our linen. The fiber comes from the stems, which have to be rotted under water, beaten to remove the woody tissue, spun and woven into cloth. This industry formed a very considerable place in the lives of the Belgians, French, and Russians who lived in the area devastated by the World War. The present high price of linen is due very largely to the destruction by the

Huns of fields of flax and especially the linen factories in Belgium. Flax is not an abundant plant in this country, and linen is harder to manufacture than cotton; hence it is more expensive. Linen is stiff, washes readily, and makes up the greater part of our table linen, collars, and cuffs.

Silkworm, cocoons, chrysalis, moth, and skein of silk. (After Weed)

Silk. — Silk is one of the smoothest and most beautiful cloths we have, as well as a good conductor of heat. The moth which produces the silkworm passes through four stages, like fleas, mosquitoes, and many other insects. The eggs are laid by the mother moth on the mulberry

leaves which are the food of the little rapidly growing caterpillars. They shed their coats as they become larger, but after a time they become quiet, shrink a little in size, and spin a wonderful covering of silk. The silk is made within the body of the caterpillar, and is given out

Sorting the cocoons of the silkworm, in Japan.

from just below the mouth, in the form of a jelly-like material. This hardens rapidly into a yellow or whitish thread. The process of weaving a cocoon takes from two to three days. The cocoons are gathered, and after placing in hot water, the silk is reeled off, very largely by hand. It takes between two and three thousand cocoons to make a pound of silk. Most of the labor is done by

hand, hence silk making must go on in countries like Japan and China, where wages are low.

Detection of frauds in clothing. — We all know that woolen cloth frequently contains much cotton. We are often sold mercerized cotton, or artificial silk, which is made by chemical means from various vegetable wastes, and it is worth while to know some simple means for detecting these frauds. If one has a microscope, it is

(a) Cotton. (b) Wool. (c) Silk.

Textile fibers.

very simple to recognize by examination the fiber of silk, cotton, linen, and woolen fabrics. (See illustration.) Some easy tests which can be made at home are the following: If we place silk fibers in hydrochloric acid, they will dissolve. By boiling wool in caustic soda for five minutes, the wool dissolves. Thus it is very easy to find out whether wool and silk are mixed with other substances in cloth. Linen threads are much stronger than cotton. A very easy way to tell linen from cotton is to place in olive oil for five minutes; if linen, the material becomes translucent; if cotton, it remains unchanged.

Experiment. — To show the effect of chemical reagents on different fabrics. *Materials:* Pieces of cotton cloth, wool, and silk of known purity. Test tubes. Beakers. Burner. Hydrochloric acid. Sodium hydroxide. Ammonia. Borax. Washing soda. Nitric acid. Sulphuric acid.

Method and Results: (*a*) *Shrinking test.* Measure pieces of cotton cloth and woolen cloth. Pour boiling water upon them and leave overnight. Dry *without stretching.* When dry measure again. Is there any shrinkage?

(*b*) Test the solubility of cotton, woolen, and silk cloth in each of the following:

1. Cold concentrated hydrochloric acid. 2. Hot concentrated hydrochloric acid. 3. Cold diluted hydrochloric acid. 4. Hot diluted hydrochloric acid. 5. Make similar tests with concentrated and dilute nitric acid, and concentrated and dilute sulphuric acid, both cold and hot.

Also make tests with cold and hot concentrated and dilute solutions of sodium hydroxide, ammonia, borax, and washing soda. Note any changes while the cloth is in the solution. Rinse and dry. Are any other changes observed? Be very careful not to get any of these solutions on your clothes or hands.

Application: What precautions should be taken in washing clothing? Can chemicals be used in finding out how much wool or other fiber there is in a certain piece of cloth? Explain.

Care of the clothes. — Clothes are to be worn both for comfort and for looks. All girls like to look attractive, but not always so with boys. How many boys have lost a good job just because of dirty collars and shirts, or carelessly blacked shoes. We may have our clothes neat and clean, even if they are not new. Underclothes should be frequently changed and washed, especially in hot weather, as they absorb the perspiration and body wastes. We should be particular about changing socks and stockings frequently, and washing the feet often as well.

A boy's appearance depends largely upon the care he gives to his clothes.

How to clean clothes. — We know that in order to take out soluble substances from clothes which have become

dirty, we must use plenty of soap and water. This water must be soft, because hard water (which has certain mineral substances dissolved in it) will not always do its work, even if soap is used. It is usually better to soak the clothes in cold water first to loosen the dirt, and later to wash in hot water. Boiling water should not be used in washing woolen goods as it renders them less porous and therefore not so warm. Alkaline soaps and other alkalies should not be used in washing woolens because alkalies dissolve wool.

Bleaching. — Sometimes we may bleach out the stains after having placed the clothing in the water, and for this purpose, nature's own ways, sunlight and the oxygen of the air, are useful, although bleaching substances, such as Javelle water, lemon juice, cream of tartar, and other substances are used. A good home project would be to find out the properties of some of the bleaching agents mentioned, and some others sold in stores. In Javelle water and in most household bleaching agents, the substance which does the bleaching is chlorine, which forms the base of some of the poison gases which have done such terrible havoc on the battle fields of the World War. Chlorine or bleaching powder must not be used in bleaching wool and silk because it stains them yellow.

Use of soap. — We have all heard of the days when our great-grandmothers made soft soap by placing together scraps of fat, butter, tallow candles, and the like, and melting them down with a strong solution of lye, which was made by treating wood ashes with lime. Now hard soap is made by the addition of certain other substances and it has become a necessity of our lives. Soap is a solvent which breaks grease up into tiny particles, form-

ing an *emulsion*, and in this condition it is carried off in the water from our hands and substances on which it is placed. The Germans during the late war suffered greatly from the lack of soap.

An emulsion seen under the microscope.

Washing powders and their use. — When water is hard or contains mineral substances, such as lime or magnesium, soap cannot well be used. It is less wasteful of soap if such waters are first softened by the addition of washing powders. These usually have washing soda as a base, which combines chemically with the lime in the water, changing it to an insoluble form, so that it does not affect the soap. Washing powders should be dissolved in a tub of water before the clothes are put in.

Neutralization. — Dirt and some stains are removed from materials, as we have seen, by solution and by bleaching. Other stains can be removed by a process known as *neutralization*. Vinegar and many fruit juices have a sour taste and will turn a piece of blue litmus paper red. A similar color change occurs when blue litmus paper is placed in the presence of any diluted acid, such as nitric or sulphuric. This is a test for *acids*. Other substances which have a bitter taste and a soapy feeling are called *bases*. Lye in soap is a strong base, as is soda, also. We find that if bases are tested with red litmus paper, it turns blue. We therefore have an artificial test for acids and bases. If we now add to a solution containing a base some acid drop by drop, and keep testing with red litmus paper, we find at length that the combination of acid and base does not affect the paper. Neither

red litmus paper turns blue, nor blue paper red, in the presence of this combination. Such a mixture as this is said to be *neutral*. In cleaning we make use of neutralization, by using acids to remove stains caused by bases, and by using bases to remove stains caused by acids.

Experiment. — Removal of spots and stains.

Materials: Strips of white cotton cloth. Congo red solution. Sodium carbonate. Lemon. Ammonia. Acetic acid or white vinegar. Salad oil. Lard. Butter. Alcohol. Gasoline. Carbon tetrachloride. Oxalic acid. Black ink. Red ink. Test tubes.

Acids and alkalies: Dye one strip of white cloth in Congo red. A second in Congo red to which is added a pinch of sodium carbonate. Dry them. What are the colors?

Let a drop of lemon juice (an acid) fall on the blue cloth. Result. Try to restore the color with ammonia. Let a drop of ammonia fall on the red cloth. Result. Try to restore the color with acetic acid or vinegar.

Acids and alkalies have opposite properties and each tends to destroy the other.

Grease spots: Dirt held by oil or grease can only be removed by the removal of the oil or grease. Test the solubility of salad oil, lard, and butter in water, alcohol, gasoline, carbon tetrachloride. Results? Suggest a good way to remove grease spots from clothing. What danger is there in using gasoline?

Fruit and ink stains: Try cold water, then hot water. Oxalic acid will remove black ink containing iron. White cotton or linen may be treated with Javelle water. The cloth must be thoroughly washed in dilute ammonia afterwards.

NOTE: Use alcohol for grass stains; dilute hydrochloric acid for rust; turpentine for paint; benzole for tar, and sulphurous acid or hydrogen peroxide for bleaching white woolens, silks, and linens.

Removal of grease. — An easy way to remove grease from clothing is to cover the grease spot with blotting paper and press with a hot iron. The grease is melted by the heat and absorbed by the blotter, which draws the liquid up into it by capillary attraction. Grease and oils

may also be absorbed by French chalk, or a mixture of starch and gasoline. Tar can often be removed by covering the substance first with lard, then heating this for some time and washing.

An interesting home project would be to make a series of experiments to determine what methods were best fitted to remove different stains from clothes. Why not try this?

Use of the score card. — This is a very important personal card and should be scored with great care. Your total score only need be given in class or in your notebook. Try to improve at once in matters where your score is low. In some of the personal matters you surely can do this. Score again in a month to see how much you have improved.

REFERENCE BOOKS

Allen, *Asia* (Chapters on Silk Production). Ginn and Company.
Allen, *Europe* (Chapters on Flax and Silk). Ginn and Company.
Bassett, *The Story of Wool.* Penn Publishing Company.
Brownell, *General Science*, Chapter IX. P. Blakiston's Son and Company.
Buchanan, *Great Inventors and Their Inventions* (Eli Whitney and the Cotton Gin). American Book Company.
Carpenter, *How the World is Clothed.* American Book Company.
Clark, *An Introduction to Science*, Chapters XI, XV. American Book Company.
From Wool to Cloth. American Woolen Company, Boston. (Free)
Fall, *Science for Beginners*, Chapter XIII. World Book Company.
Gannett, *Commercial Geography.* American Book Company.
Hunter, *A Civic Biology*, Chapters X, XV. American Book Company.
Sargent, *Plants and Their Uses.* Henry Holt and Company.
Bodmer, *The Book of Wonders* (Story of Cotton, Wool, and Silk). Presbrey Syndicate, N. Y.
Toothaker, *Commercial Raw Materials.* Ginn and Company.
Turner, *The Study of Fabrics.* Appleton and Company.
Van Buskirk and Smith, *The Science of Everyday Life*, Project XIV. Houghton Mifflin Company.
Weed, *Chemistry in the Home.* American Book Company.

SCORE CARD, CLOTHING, BATHING, VENTILATION

	Score		
	Perfect Score	My Score	
			Total
Outer clothes			
Clothes			
fit well but loosely worn	2	....	
sensible in color and pattern	2	....	
well washed and mended	2	....	
Collar and shoes clean	2	....	
Shoes sensible width and style	2	....	....
Underclothes			
Mesh underwear worn	2	....	
Woolen underwear in winter	2	....	
Socks and stockings changed every other day	2	....	
Underclothes changed every other day in summer, oftener if odor is noticeable	2	....	
Wear warmer outer clothes in winter or on going out of doors in cold weather	2	....	....
Bathing			
Tub bath weekly: twice a week in summer	2	....	
Feet bathed every other day	2	....	
Shower or cold rub in morning	2	....	
Face, neck, and ears washed with soap and water every morning	2	....	
Hands washed before and after meals and after going to toilet	2	....	....
Bedroom hygiene			
Window space equal to $\frac{1}{4}$ floor area	2	....	
Windows screened full length	2	....	
Windows open top and bottom at night or sleeping porch	4	....	
No hangings	1	....	
No draft on bed	1	....	....
Home ventilation			
Ventilation in every room in house	2	....	
Air seldom seems "close" or "stuffy"	2	....	
Sunlight not kept out by heavy curtains	2	....	
House aired thoroughly once a day	2	....	
Drafts avoided	2	....	.....
TOTAL	50		.....

PART IV. LIGHT IN THE HOME

CHAPTER XV

SOURCES OF LIGHT FOR HOME USE

Problems. — 1. *To understand the importance of light and eyes.*

2. *To see what important properties of light we utilize.*

3. *To understand how my home is lighted by natural means.*

4. *To understand how my home is lighted by artificial means.*

5. *To compare the different types of lighting.*

Experiments and demonstrations. — 1. To show degrees of transparency.

2. To show the advantage of the mantle in gas lighting.

3. To show how electricity may be changed into light.

4. To show the advantage of tungsten over carbon lamps.

Project I. — TO IMPROVE THE LIGHTING OF MY HOME.

1. Take up question of quantity of light, natural and artificial, for various kinds of work, and whether other devices would cut down expense of artificial light.

2. If some room is poorly lighted in daytime, can you devise a remedy?

3. What about shades, glare, and harmful habits in the use of light?

4. Have you a satisfactory switch or button installation for turning lights on and off? Additional lamps needed anywhere?

Suggested Projects.

1. MAKE A TOY PERISCOPE.

2. TO USE A LARGE GLASS AS A MIRROR FOR "STAGE TRICKS." See *Book of Magic*, HOPKINS.

Light and mankind. — Have you ever, while looking out of the window, put your hands over both eyes, and then tried to imagine what life would be without light? What a dismal place the earth would be! We have come to depend very much upon the sun and its radiant energy, which travels to us across an ether space just as heat does, and our homes have been planned so that we can make use of all sources of light, both natural and artificial. Much of our light comes from the sky rather than directly from the sun. The area of the sky visible from our windows is very important, because it is from this that we get most of our light. The sun at midday is so bright we can look at it only with strongly smoked glasses, and we all enjoy the long twilight of summer following the light of day, when no sun is visible.

The sun is the source of all energy.

How does the sky give light? — This seems a simple question, but in order to understand how light comes to us, we must first learn some very important properties of light. If we place a lighted candle or lamp on the table, we can all see it. If we hold a piece of window glass in front of it, the glass does not in any way obstruct the light. We call such an object *transparent*. On the other hand,

a piece of oiled paper or ground glass, if placed in front of the candle, allows a certain amount of light to go through, but we cannot see the flame distinctly. Such a substance is called a *translucent* body. If we now take a board or piece of sheet metal and hold it before the light, it prevents any light from reaching our eyes. Such a substance is called an *opaque* body, and behind such a body, the space from which light is excluded is called a *shadow*. Light passes through transparent bodies without much loss or scattering of the rays. Less light passes through translucent bodies, and there is much scattering of the rays of light, while no light at all passes through opaque bodies.

Which obstructs the most light? Which the least?

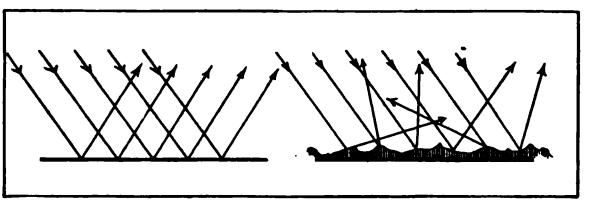
Experiment. — Transparency.

Hold glass, oiled paper or ground glass, and sheet metal in turn between your eyes and a light. Explain the different effects.

Reflection and its reasons. — If you take a smooth surface, such as a mirror, and allow light to fall on it, a strong beam is reflected, while from a roughened surface no such beam passes, the light being scattered from the irregular surface, or diffused. It has long been known that light striking a flat smooth surface would be reflected from it at exactly the angle at which it strikes it. If, in a beam of sunlight the rays which travel parallel to each

other strike a roughened surface, they are thrown off in different directions and produce *diffused* light.

Light from the sky. — We are now better able to understand why we get light from the sky. The air always contains particles of solid and liquid material, as dust, and moisture. It is very seldom that the air is clean, and then only at points far above the earth, and even in this air there are enough of these dust particles to divert the



Which surface diffuses light?

rays of light from the sun. Since the surfaces of these particles are irregular, the light is diffused in all directions. Thus it is that particles in the air above our homes, receiving sunlight, divert some of these rays to us, no matter where we may be situated. If there were neither air nor any other substance about the earth, then the sky would appear dark, and we would only get light directly from the sun, the moon, and other bodies in the heavens, the stars and the planets.

Natural light in the home. — Fortunate is the boy or girl who lives in a detached house, for direct sunlight bathes the house on bright days, and some of it is sure to enter. Within the crowded city with its tall buildings standing close together, with one home piled on top of another, as we have in apartments, people are fortunate if they get direct light in more than one or two rooms, and

in many city homes no direct light enters at all. Light is of much importance to us, not only because we see objects by the light which comes from them, but also because it benefits health, and destroys bacteria. We must also remember, if we live in the country, that too much shade and too many trees are as bad as too few. Trees,

A house with plenty of light.

hills, and buildings, as well as porches and other overhanging parts of the house, all cut off light from our houses.

Regulation of sunlight in the home. — It is a very good rule in planning a house to have the window space of a room one fourth to one fifth of its floor space. This will give a sufficient amount of light for most purposes. The bedroom may have less window space, but no bedroom should ever shut out light and air by having window hangings and draperies. If the wall paper and woodwork of the room are dark, the room itself will be dark, for dark objects absorb light. As a rule the ceiling should be lightest, the walls a little darker, and the floor still darker.

This gives good distribution of light within the room. If a room is too light, and at the same time too hot in summer, we can adjust the amount of light entering by means of blinds or awnings. The Venetian blind or porch shade is a convenient type to use, for it shuts out the sun's rays without preventing a circulation of air.

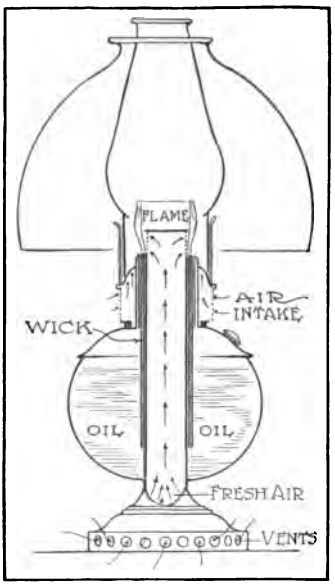
Both these rooms receive the same amount of light. One has dark wall paper and the other light.

Artificial light in our homes. — It was not so many years ago that candles were the sole source of light in our homes, and at the present time, candle light lends a pleasant glow to birthday and Christmas parties. Up to the time of the Civil War, tallow candles, pine knots, and heavy oils were common sources of light for reading. People to-day use eighteen times as much light as they did one hundred fifty years ago, and at one third the cost.

The first gas plant in America was started at Philadelphia in 1815. Then candles cost two and one-half cents each and would burn for seven hours. About the middle of the nineteenth century the whaling industry was at its height, and sperm oil was burned in lamps. Petroleum was first used in 1858 for lighting purposes, and so rapidly did its use grow that in 1860, two million barrels were produced, and to-day, almost three hundred million barrels a year. Although artificial gas was slow in its introduction, yet it now plays a very important part in the lighting of our

houses. About 1890, electricity began to come into general use for lighting purposes, and is now one of our best known servants in the home.

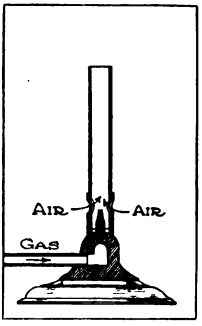
Kerosene light. — Kerosene oil lighting is still one of the common methods of illumination, especially in country homes. When oil first came into use, it burned with a smoky flame, until in 1783, Argand, a Swiss physician, made a ring-shaped wick with a central draft. This allowed convection currents to be set up inside the wick, and thus a larger flame could be fed with oxygen. Flat wick lamps which give smokeless flames are now in common use, but the central draft lamp gives more light. The gasoline lamp and acetylene lamp, although used in many places, are not in sufficiently common use to warrant a full description here.



Central-draft oil lamp.

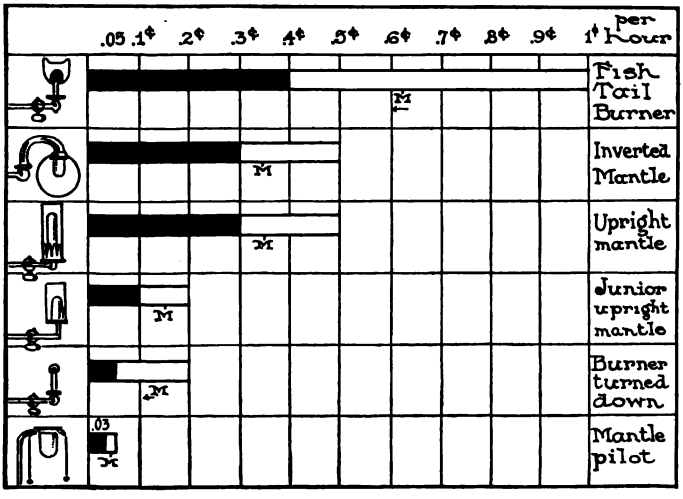
Gas in the home. — Although not all of us are fortunate enough to have either natural or artificial gas in the home, yet we should know something about the gas burner and its uses. When a candle burns, as we know, the paraffin wax melts, becomes a vapor, and burns. You can prove that the gas inside of the candle flame is not on fire by passing a small tube into it, leading out the gas, and then lighting it. When gas, passing from the outlet of an ordi-

nary burner, has not been previously mixed with air, a yellow flame results. This is a very wasteful type of burner. The Bunsen burner, in which air is mixed with the gas, gives a clean hot flame which is not very luminous. A combination of this type of burner, which produces much heat, with a mantle which glows when heated, gives us the Welsbach light. Welsbach mantles are made from compounds of two rare metals, thorium and cerium, which when heated to a high temperature give the bright light we are so familiar with.



A Bunsen burner.

Experiment.—To show the advantage of the mantle in gas lighting. Connect a common fishtail burner and a Thorp gauge to the gas supply. Light the burner and see how many cubic feet of gas per hour are



Effect of gas appliance on cost of gas. Black = minimum; Black and white = maximum; M = mean cost per hour.

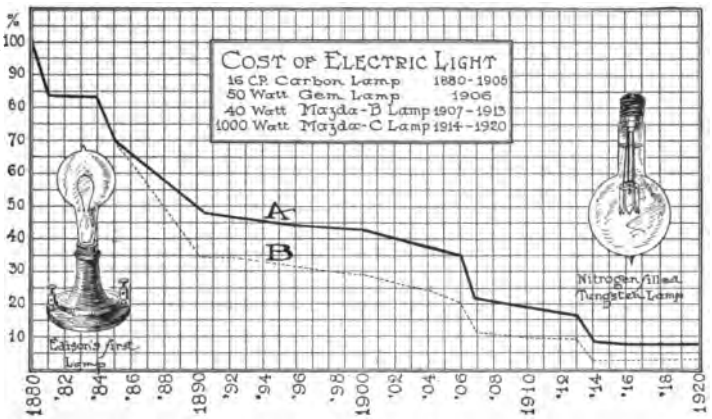
registered. Replacing the fishtail burner by a mantle and burner, how does the light produced in the two cases compare? How much gas is being consumed in the latter case? What is your conclusion? (If a Thorp gauge is not available, test the gas consumed in a specified time by observing the small indicator of the gas meter dial.)

The first electric lamp. — It is due to Thomas Edison that we have the incandescent light. The story of its invention is well known. He worked for a great many years and spent hundreds of thousands of dollars in the perfection of the bulb light, patented in 1880, which he furnished finally with a carbon filament, made of bamboo. The way in which this filament gives light can be explained better after we have performed an experiment to illustrate what makes electricity give light. Electricity is a form of energy which is conducted easily by metals. We have all seen that the pipe conducting liquids in the house offers resistance to them so that they do not flow so easily. In somewhat the same way wires offer resistance to electricity. That part of the electrical energy used in overcoming this resistance to the wire conductor is changed into heat, which when intense enough produces light. This may be shown by the following experiment:

The carbon filament incandescent lamp and the modern tungsten lamp.

Experiment. — To show how electricity may be changed into light. (To be performed by the teacher.)

Suspend a ten-foot length of fine iron wire (No. 26) from insulated supports. Fasten one wire of a 110-volt circuit to one end of the iron wire, and bring the other end of this circuit in contact with the other end of the wire. Move the end of the circuit wire along, shortening the length of the iron wire until it becomes red hot. All this heat energy is produced at the expense of electrical energy. As the wire is shortened the heat increases. The hotter the wire, the greater per cent of electrical energy is changed to heat.



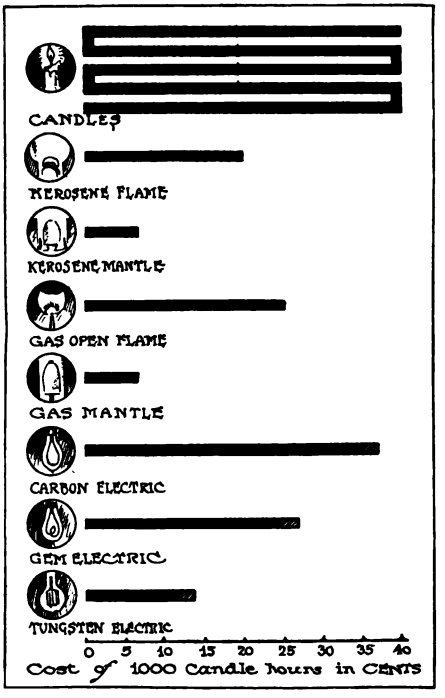
Graph showing decrease in cost of electric lighting in forty years. A is the reduction due to lamp improvement only; B, due to lamp improvement and reduced rates for current.

We thus see from the result of this experiment that it is more economical to use electric bulbs which contain filaments which can be raised to high temperatures. Why?

Experiment. — To show the advantage of tungsten over carbon lamps. Connect one or more small carbon lamps in a circuit with a kilowatt-hour meter. Find the electrical energy used in running these lamps for a definite time, say one hour. Replace the lamps by an equal number of small tungsten lamps (25 watt), and find the electrical energy consumed during an equal interval of time.

Each carbon lamp gives 16 candle power, and each tungsten lamp gives 20 candle power. Reckoned on the basis of candle power, what is the ratio of cost of running the two types of lamps?

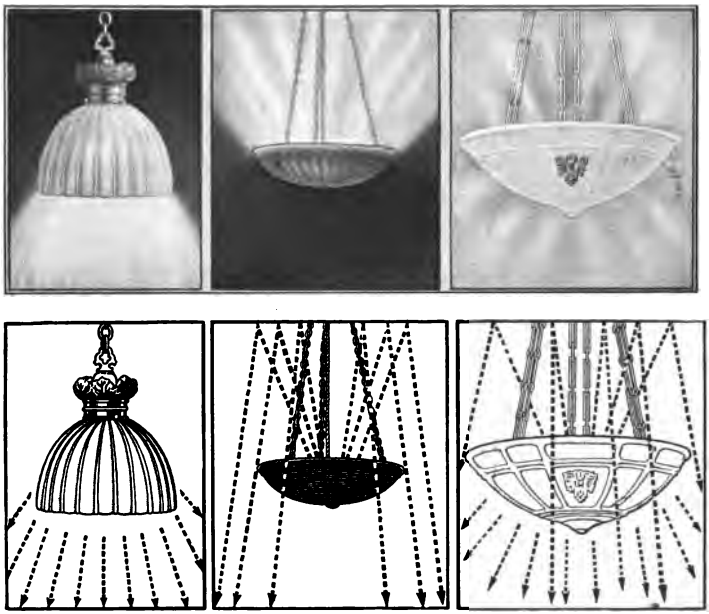
The tungsten light. — The old carbon filament is rapidly being replaced by the tungsten lamp. The carbon filament can be heated to 1850 degrees Centigrade, while the tungsten filament can be heated to 2100 degrees Centigrade, and in bulbs which are filled with nitrogen, the temperature may go still higher; therefore we get a much brighter light from the tungsten lamp. A one hundred candle power tungsten, nitrogen-filled bulb requires only about one seventh as much electricity as the one hundred candle power carbon lamp. The table on the following page shows some common light intensities. A good home project would be to find out the difference in the cost of lighting your home with the fishtail gas flame, the Welsbach gas flame, carbon filament electric lights, and tungsten filament lights.



This chart, suggested by the Bureau of Standards, shows the relative cost of light from different illuminants, based on the following prices: candles, 12¢ a pound; kerosene, 15¢ a gallon; gas, $1 per 1000 cu. ft.; electricity, 10¢ per kilowatt-hour. Solid black represents cost of fuel, and shaded, cost of mantles and bulbs. Revise this chart in your notebook to agree with cost of these illuminants in your own city or town.

TABLE OF INTENSITIES OF COMMON TYPES OF LIGHTING

The common carbon incandescent lamp	16 candle power
The small tungsten incandescent lamp	20 " "
The fishtail gas flame	22 " "
The Welsbach gas flame	60 " "
A 100-watt tungsten incandescent	92 " "



Explain how these pictures illustrate *direct*, *indirect*, and *semi-indirect* lighting.

Methods of lighting. — Several ways of lighting by electricity are now in use. In *direct lighting*, the light is thrown directly from the lamp or by a reflector to the place where it is used. This produces a glare in some directions and has some disadvantages which we shall study in connection with the eye. Direct lighting is economical because little light is lost through diffusion or absorption.

In *indirect lighting*, an opaque reflector comes between the eye and the bulb and all light is directed upward to a white or light colored ceiling. Here the light is diffused, and this resembles daylight in its general effect. It is not economical, but is pleasant and restful for the eyes. In *semi-indirect lighting*, a translucent reflector throws most of the light to the ceiling. Some light passes through the shade. There is no glare in this system, and its cost is intermediate between the other two systems.

Use of the score card. — Here the boy and girl in the country will probably have the advantage in natural lighting, but the city child will perhaps have better conveniences in artificial light. Study carefully to find out the relative cost of your lighting system and make inquiries as to the cost of light in your town, if you have gas or electricity. What improvement in your home lighting can you suggest?

SCORE CARD. LIGHTING MY HOME

				My Score	
					Total
SUNLIGHT	Three fourths of all rooms have direct sunlight (4)	Half rooms have direct sunlight (2)	No rooms have direct sunlight (0)	....	
	All rooms well lighted by natural light. No artificial light needed until after sundown (2)	Half rooms well lighted by natural light; no artificial light needed until after sundown (1)	No rooms in which artificial light is not needed before sundown (0)	....	
	Home not directly shaded by trees or other buildings (2)	House partly shaded (1)	House densely shaded (0)	....	
	Well-lighted airy cellar (2)	Cellar not light but airy (1)	Cellar dark and musty (0)	....	....
WINDOWS AND WALL PAPER	Window space at least ¼ floor space (av. all rooms) (4)	Window space at least ⅙ floor space (2)	Window space less than ⅙ floor space (0)	....	

SCORE CARD. LIGHTING MY HOME — *Continued*

				My Score	
					Total
WINDOWS AND WALL PAPER	Awnings or shutters provided (2)	Shutters, no awnings (1)	No shutters or awnings (0)	....	
	No dark hangings at windows (2)	Dark hangings at some windows (1)	Dark hangings at most windows (0)	....	
	No rooms having dark wall papers (2)	One half rooms having dark papers (1)	Three fourths rooms having dark wall paper (0)	....	....
COST OF ARTIFICIAL LIGHTING	Economical (Consult tables, page 245, and diagram, page 248) (10)	Moderately economical (5)	Expensive (0)	....	....
PROPER LIGHTING FOR ALL KINDS OF WORK	Light used gives no glare and does not shine in eyes when reading or at dining table (2)	Sometimes direct light in eyes (1)	Usually direct light in eyes (0)	....	
	Strong light for sewing (2)	Fair light for sewing (1)	Poor light for sewing (0)	....	
	Kitchen well lighted (2)	Good light at sink or range, not at both (1)	Poor light all parts of kitchen (0)		
	Lights both sides of mirror in bathroom (2)	Light on one side bath mirror (1)	No light near bathroom mirror (0)	....	
	No carrying of lights from one part of the house to another (2)	Necessary to carry light to some parts of the house (1)	Always necessary to carry light from one room to another or to light with matches (0)	....	....
CONVENIENCE OF LIGHTING SYSTEM	Gas or electric wall switches (2)	Gas or electric control at jet or socket (1)	Oil lamps used (0)	....	
	Switch on one floor turns on light on other floors (2)	Switch control of light upstairs and down but not to cellar (1)	No switch control from different floors (0)	....	
	Either floor sockets for electric connection or extra gas connection for small heater or gas iron (2)	Some, but insufficient extra connections (1)	No extra connections (0)	....	
	Different amounts of light easily obtained in most rooms (2)	Variation of light intensity possible in only a few rooms (1)	Variation of light difficult in any room (0)		
	Lighting service never interrupted (2)	Service occasionally interrupted (1)	Service frequently interrupted (0)	....	....
GRAND TOTAL			PERFECT SCORE 50		

REFERENCE BOOKS

Adams, *Harper's Electricity Book*. Harper and Brothers.

Bachman, *Great Inventors and their Inventions* (Edison). American Book Company.

Barber, *First Course in General Science*, Chapter I. Henry Holt and Company.

Brownell, *General Science*, Chapter X. Blakiston's Son and Company.

Burns, *Great Inventions* (Electricity). Harper and Brothers.

Clark, *An Introduction to Science*, Chapters XXVI, XXX. American Book Company.

Gowin and Wheatley, *Occupations*, Chapter IX. Ginn and Company.

Hodgdon, *Elementary General Science*, Chapters X, XI. Hinds, Hayden, and Eldredge.

Inventor and Lamp (Lecture 8). General Electric Lecture Service, Schenectady, N. Y.

Official Handbook, Boy Scouts of America. Doubleday, Page and Company.

Lynde, *Physics of the Household*. The Macmillan Company.

Smith and Jewett, *Introduction to the Study of Science*, Chapter IV. The Macmillan Company.

Tappan, *Modern Triumphs* (Edison and Electric Light). Houghton Mifflin Company.

Tappan, *Wonders of Science*. Houghton Mifflin Company.

Van Buskirk and Smith, *The Science of Everyday Life*, Project XII. Houghton Mifflin Company.

CHAPTER XVI

IMPORTANCE OF OUR EYES

Problems. — 1. *To see how the eye resembles a camera in structure.*

2. *To find out what colors are.*

3. *To learn what the common defects of the eye are and how to remedy them.*

4. *To find out the defects of my own eyes.*

5. *To learn rules for proper care of the eyes.*

Experiments and demonstrations. — 1. To show how the pupil of the eye changes size in looking from a dark room toward a strong source of light.

2. To test my own eyes for defects.

Project I. — TO REMEDY ANY EYE DEFECTS YOU MAY HAVE.

1. Have a competent person test your eyes for astigmatism, nearsight, farsight, and color blindness. You can tell if you have eyestrain.

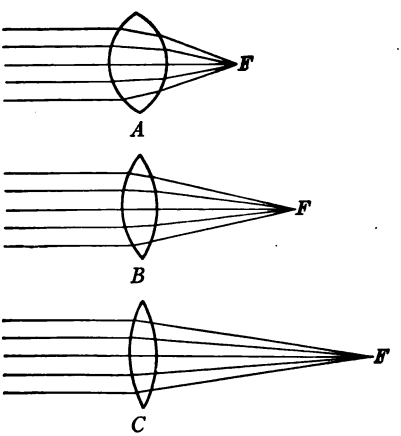
2. Remedy any serious defects.

3. Explain the science involved in the eye defect and in the application of the remedy.

How we see. — One of the saddest results of the World War is seen in a hospital where men blinded by gas or other causes grope their way around in somber darkness. How we pity them! The loss of sight would be one of the most terrible things that could happen to us. Then why

should we abuse these delicate organs we call the eyes? The daytime is not long enough for us, so we provide ourselves with artificial light and keep our eyes at work part of the night. We read fine print in dim light, and injure our eyes in a hundred ways. Our eyes are of so much importance to us that it seems wise to devote an entire chapter to them and their care.

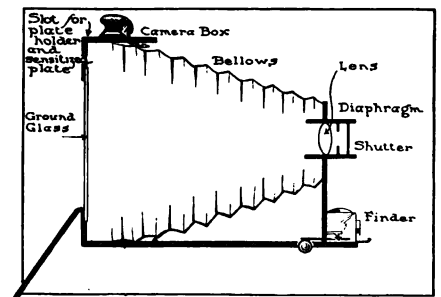
Lenses and what they do. — We have all tried to set fire to a pile of leaves or paper with a burning glass. An ordinary reading glass found sometimes on the library table is a common example of a simple lens. If we look at it in cross section, we find that it bulges outward in the middle in both directions. We call such a lens *double convex*. If we hold such a lens so that the sun shines through it, and move a piece of paper toward or away from it, one place will be found where only a tiny spot will be lighted, but this will be extremely bright, and enough heat may be concentrated to set the paper on fire. This point at which the sun's rays have been brought together (see *F* in figure) is called the *focus*. When light passes through the air to the glass, it moves in parallel rays, but the glass bends the rays so that they come together at one point. This point is called the *principal focus* of the



Which lens has the shortest and which the longest focal length?

lens, and the distance from that point to the center of the lens is called the *focal length.* You can easily measure the focal length of a lens by this method.

The camera. — The study of a camera will help us to understand the parts of the eye. If we carefully note the parts of the camera shown in the illustration, we find that it is a light-tight box painted black on the inside to absorb all light rays, and having a lens, a diaphragm for changing the size of the opening, and a shutter in front which controls the time of the exposure of the photographic plate or film which is placed at the opposite end of the camera. In a photographer's camera, such as is shown in the illustration, a ground glass is placed at the end where the plate is held when an exposure is made.



Essential parts of a plate camera.

Experiment. — To show how a lens is used in focusing

Materials: Double convex lens. White screen. Large carbon bulb.

1. Focal length.

Hold a double convex lens in sunlight at right angles to the rays. Place a screen of white paper back of the lens. Adjust the distance between them until the spot of light (the sun's image) is the smallest. Measure the distance from the lens to the screen. This distance is called the *focal length* of the lens.

Compare the focal length of a thick lens with that of a thin lens by this method.

2. Focusing as done in the camera.

Hold a double convex lens about three times its focal length from a large carbon lamp which is lighted in a dark room. Move a screen of

white cardboard back and forth until a position is found where a sharp image of the filament is seen on the screen. Move the light farther away. What must you do with the lens to give a second sharp image on the screen? Compare the two images. Move the lens towards the light until an enlarged image results. Explain how this experiment illustrates the use of a lens in the ordinary camera and also in the enlarging camera.

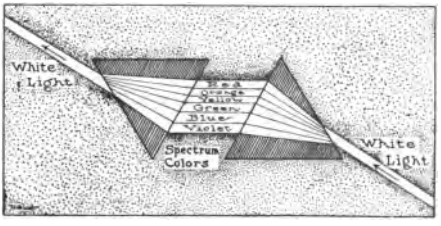
What is color? — If you have ever watched waves coming in to the shore, you may have noticed that sometimes the distance beween two successive waves is quite great, and sometimes it is much less. We have learned that light is caused by waves of ether which come to us from the sun or from other lighted objects. Only a very small portion of all the ether waves affect our eyes, and give us the sensation we call light. Ether waves producing light differ in length, the longest being one thirty-three thousandth of an inch in length, and the shortest that we can see, one sixty-six thousandth of an inch in length. The longest of these visible waves causes the sensation of red, and the shortest gives the sensation violet, while all other colors come between these. *Color*, then, is a property of light waves, and each particular color is due either to waves of some particular length, or to mixtures of waves which produce different colors.

How we see color. — When all the different light waves from the sun are mixed together, white light is produced, as we see when sunlight is reflected by white paper. White substances are those which reflect all sunlight. Black objects are those which absorb all of it. Any object which absorbs all the light waves except the very long ones is red, because it reflects to your eyes only the red waves. In the same way, any object which absorbs all the waves except the very short ones would look violet in color. This seems very strange, but we can prove that light is

made up of these various colors by passing it through a prism, a triangular shaped glass such as we often see in the candelabra in old houses. If a ray of sunlight were passed through this prism to a screen in a darkened room, we could see all the rainbow colors of the *spectrum*. If we allowed this light to pass through a second prism placed in a reversed direction (see diagram), the colors would again be brought together, and passed out as white light. The rainbow is nothing more or less than light passing through falling drops of water, which act as prisms, thus separating light into its elements, red, orange, yellow, green, blue, and violet.

A prism separates white light into colors of the spectrum.

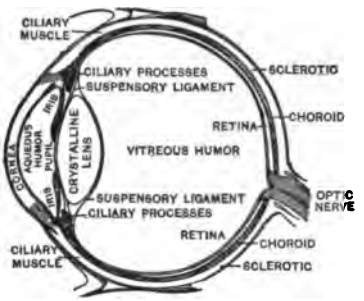
Structure of the eye. — We are now ready to learn something about the structure of the eye. Our eyes are among the most delicate and wonderful structures in the body. We abuse them constantly, yet they serve us well. Notice how well they are protected by being set in a bony socket, and how admirably the lashes serve to keep out dust and dirt. See, too, how tears flow every time any dust gets upon the delicate membranes of the eye. Also observe, how the



The spectrum colors can be reunited by a second prism so as to produce a beam of white light.

eye can be turned in different directions, due to the little paired muscles which serve to move the eyeball.

If we study a section as shown, by cutting the eyeball in halves from front to back, we find that it is more like the camera than it is on the surface. In the front there is a transparent lens which makes a little picture at the back of the eye, just as the camera lens makes a picture. This lens, however, is not fixed in shape like that of a camera, but is flexible, and is made thicker or thinner by movement of delicate muscles, thus doing away with the necessity of moving the lens forward or backward in order to get a picture in focus.



Section of the eye. Find the parts which correspond to those in a camera.

The main portion of the eye is filled with a colorless substance, the *vitreous humor*, while back of this lies a pigmented receiving organ connected by nerves with the brain, known as the *retina*. It is on this sensitive surface that our images are received and sent to the brain by the optic nerve, so that we really see in the brain, although the picture is received on the retina. There are three coats covering the eyeball, a tough outer coat, the *sclerotic*, a middle coat, the *choroid*, while the inner coat is the *retina*. These coats are open at the front, and the choroid, which is filled with *pigment*, or color-bearing material, makes a kind of curtain. It is this curtain, called the *iris*, which gives the color to a person's eye. The iris controls the amount of light which passes through the hole, or *pupil*,

into the inside of the eye, just as the diaphragm in the camera controls the light. On a bright day, would you expect the pupil of the eye to be larger or smaller than on a dull day? Why?

Experiment. — To see the pupil of the eye change in size.

From a room in which all the other windows are darkened look out of the window into a very bright sky for a moment. Examine the eye in a mirror. Then turn quickly and look at your eyes in the mirror with your back to the light. Result? Explain.

Control of focusing. — The eye adjusts itself quickly to see objects at different distances. This is done by means of tiny muscles called the *ciliary* muscles, which change the thickness of the lens. A flat lens focuses well on distant objects, while a thick lens focuses on objects near at hand. If you look at an object some distance off, and then suddenly holding a book before your eyes try to focus on the page, you will find that the print is blurred for a moment before you are able to see. This change of focus is called *accommodation.*

How the eye adapts itself to different intensities of light. — It has been found that different intensities of light in the home are desirable for different kinds of work. The following table gives the intensity in foot candles, which means the amount of light a candle would give at a distance of one foot from an object.

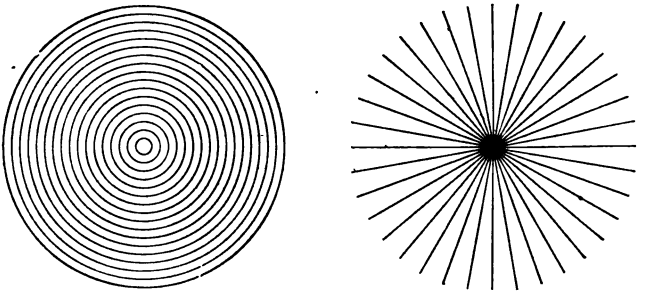
	Desirable at Times	Minimum
Hall and stairways . .	1 — 2.5 foot candles	0.5 foot candle
Living room and dining room	3 — 6 foot candles	1.5 foot candles
Sewing room	6 — 12 foot candles	3. foot candles

The eye is able to adjust itself to different amounts of light, within rather wide limits, without harm. In order to avoid straining the eye, it is necessary to have enough light. Much harm is sometimes done when we are young by trying to read in insufficient light; just as much harm has been done by looking into a blinding light, or trying to look at the sun, as some youngsters do at times to " stunt " each other.

How does the eye adjust itself to different intensities of light?

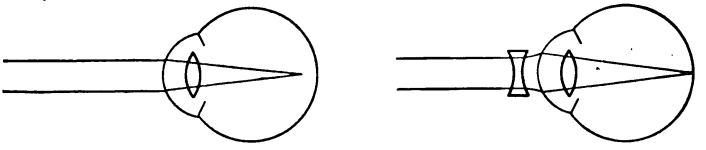
Some defects of the eye. — Although the eye is a wonderful piece of mechanism, it has several common defects. Fortunately, due to a study of the eye and of the science called *optics*, we are now able to remedy most of these defects very easily, especially by the use of glasses. It is estimated that one person in every four has some defect in vision. Nearly twenty-five per cent of the school children in Massachusetts and over thirty per cent of the school children in New York have eye trouble of some kind. The most common defect of the eye is *astigmatism*. This is usually due to a slight uneven curvature of the cornea, or the lens. It can easily be discovered by use of the diagram on page 261. Look at either of the figures with one eye closed. If some of the lines appear blurred or thicker than others astigmatism is present and should be corrected with glasses, as this defect is a frequent cause of headache.

The next most common defect is *nearsightedness*. In this case the eyeball is too long from front to back, or the



Diagrams to be used in testing for astigmatism.

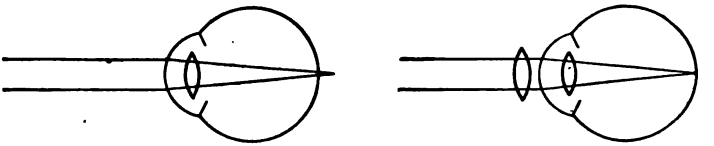
lens is too thick, so that the image of distant objects is focused in front of the retina. This tends to make one squint the eye, and also to hold the object near to the eye. Nearsightedness is quite common in children, and is easily corrected by the use of glasses which place the focus in the right place.



Nearsightedness is remedied by means of concave eyeglass lenses.

Farsightedness is another common defect. In farsightedness, the eyeball is too short, or the lens too thin, and the image if it could be found would fall behind the retina. Hence we get a blur on the retina. This is a more difficult defect to recognize, because people often do not know its presence until they are made aware of it by constant headaches. As a person grows older, he has a tendency to become farsighted. It is frequently the case that elderly persons when reading need one kind of lens, and for ordinary purposes, a second lens. For this purpose a double

glass, called *bifocal*, combining the two lenses in one is often used.



Farsightedness is remedied by means of convex eyeglass lenses.

Testing of eye defects. — A very simple exercise for testing most eye defects is given in the following laboratory experiment.[1]

Experiment. — To test my own eyes for defects.

A. Test for Farsightedness

Method: Using the Snellen test cards, locate the finest line that can be read at a distance of 20 feet. Test each eye separately, covering the eye not in use with a piece of cardboard. Then place a pair of spectacles with a 50 plus diopter lens before the eyes. If as fine or a finer line can now be read, then farsightedness is present and an oculist should be consulted, especially if headaches or other symptoms of eye defects are present. Farsightedness is one of the most frequent causes of eyestrain and is hard to detect because the eyesight seems so good.

How far away can you read these letters? Measure the distance. Twenty feet is a test for the normal eye.

B. Test for Nearsightedness

Method: Use the above-mentioned charts. Determine the finest type you can read at a distance of 20 feet. If it is larger than the 20/20 line, then your vision is defective and you should probably consult an oculist, especially if you have any symptoms of eyestrain.

[1] This test was prepared by Dr. Lucius J. Mason of the Department of Biology, DeWitt Clinton High School, New York.

C. Test for Astigmatism

Method: Use the clock dial disk at 20 feet. If some lines are blacker than others, then astigmatism is present. If headaches or other symptoms are present, then you should consult an oculist and have glasses fitted to correct this trouble.

Eyestrain. — Eyestrain frequently results from attempts to overcome defects of the eye, and also by putting the eyes to too severe use, thus taxing the blood vessels of the eye, and the nerves, which in turn affect the nerves of the head and stomach. The following are some of the things which we often call upon the eye to do:

1. Change focus for different words in the line. This is because they vary in their distance from the eye, and only in two places are the eyes equally distant from the words being read.

2. Insufficient light. The illumination of the object is of extreme importance as the light fades at close of day. For then the white paper of a printed page becomes darker and darker, until finally it reflects very little more light to the eye than the printed letters; consequently the letters no longer stand out, and we have great eyestrain.

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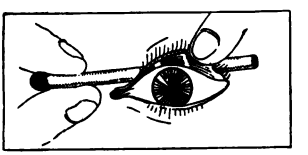
Removal of cinders. — Sometimes particles of dust or cinders get into the eye. These are usually washed out by tears which flow as a result of the irritation. Sometimes, however, they have to be removed. In the case of the lower lid, there is little trouble; if one pulls the lid down the speck can easily be removed with the use of a clean handkerchief. The upper lid is more difficult to pull back. In order to do this successfully, have the person look downward, place a small pencil against the upper portion of the lid, take hold of the eyelashes, turn the lid upward and back over the pencil, and the lid is in such a position that the speck can easily be located. Sometimes a tiny sharp-pointed bit of glass or cinder becomes embedded in the surface of the cornea. A drop of olive oil in the eye prevents irritation until with the help of an expert physician it can be removed.



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Hunter, *Laboratory Problems in Civic Biology*, Chapter XXIV. American Book Company.
Ritchie, *Physiology and Sanitation* (Chapter on Eye). World Book Company.
Routledge, *Discoveries and Inventions of the Nineteenth Century*, pages 374–402; 529–551. Routledge.
Stiles, *Human Physiology*, Chapter XI. W. S. Saunders Company.
Thompson, *Boys' Book of Sports*, pages 291–301. Century Company.

SCORE CARD. CARE OF MY EYES

	Score	
	Perfect Score	My Score
Use different intensities of light for different kinds of work. (See table, page 259)	2.5	
Never look into "blinding" light	2.5	
Do not use flickering light for work	2.5	
Do not use dim light for reading	2.5	
Do not read on cars	2.5	
Correct position of light when reading. (No glare on paper; light from above)	2.5	
Correct position of light when writing. (Light over left shoulder for right-handed people)	2.5	
Do not read fine print for long period of time	2.5	
Do not use too strong a light for reading. Lights that make glare are bad	2.5	
Never face strong light when reading or doing other fine work	2.5	
Strong light used for sewing or other fine work	2.5	
Do not use eyes when they ache	2.5	
Do not use eyes when tired	2.5	
Bathe eyes in hot salt water if they ache	2.5	
Wash frequently in boracic acid if inflamed	2.5	
Can remove dirt by rolling lid	2.5	
Eyes examined by oculist once a year	2.5	
Glasses adjusted by *oculist*, when needed	2.5	
Glasses used constantly in case of eye defects	2.5	
Eyes tested and found glasses not needed	2.5	
TOTAL	50.0	

PART V. THE HOME AND ITS SURROUNDINGS

CHAPTER XVII

MAKING AND BEAUTIFYING THE HOME

Problems. — 1. *To find out the chief materials of which our houses are made.*

2. *To see what arrangement of rooms in the house is desirable.*

3. *To learn what the essential qualities of the important rooms in the house are.*

4. *To see what decorations can be used to make the house beautiful.*

Experiments. — 1. To discover the relation of markings in trim to the cutting of wood.

2. To make concrete of various mixtures and compare properties.

Project I. — To PLAN THE IDEAL HOUSE.

1. Make floor plans of your own house.

2. Study plans made by others. Cut plans and photos from magazines. What are their good and their bad features?

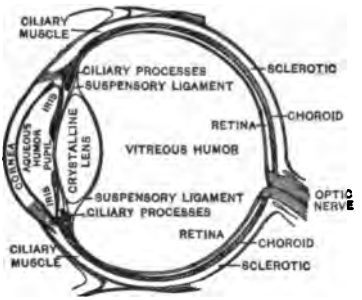
3. Study your friends' houses.

4. Finally make floor plans for what you consider an ideal house for your own family.

5. Discuss materials you would select for building and give reasons, and tell how you would decorate the house within.

eye can be turned in different directions, due to the little paired muscles which serve to move the eyeball.

If we study a section as shown, by cutting the eyeball in halves from front to back, we find that it is more like the camera than it is on the surface. In the front there is a transparent lens which makes a little picture at the back of the eye, just as the camera lens makes a picture. This lens, however, is not fixed in shape like that of a camera, but is flexible, and is made thicker or thinner by movement of delicate muscles, thus doing away with the necessity of moving the lens forward or backward in order to get a picture in focus.



Section of the eye. Find the parts which correspond to those in a camera.

The main portion of the eye is filled with a colorless substance, the *vitreous humor*, while back of this lies a pigmented receiving organ connected by nerves with the brain, known as the *retina*. It is on this sensitive surface that our images are received and sent to the brain by the optic nerve, so that we really see in the brain, although the picture is received on the retina. There are three coats covering the eyeball, a tough outer coat, the *sclerotic*, a middle coat, the *choroid*, while the inner coat is the *retina*. These coats are open at the front, and the choroid, which is filled with *pigment*, or color-bearing material, makes a kind of curtain. It is this curtain, called the *iris*, which gives the color to a person's eye. The iris controls the amount of light which passes through the hole, or *pupil*,

into the inside of the eye, just as the diaphragm in the camera controls the light. On a bright day, would you expect the pupil of the eye to be larger or smaller than on a dull day? Why?

Experiment. — To see the pupil of the eye change in size.

From a room in which all the other windows are darkened look out of the window into a very bright sky for a moment. Examine the eye in a mirror. Then turn quickly and look at your eyes in the mirror with your back to the light. Result? Explain.

Control of focusing. — The eye adjusts itself quickly to see objects at different distances. This is done by means of tiny muscles called the *ciliary* muscles, which change the thickness of the lens. A flat lens focuses well on distant objects, while a thick lens focuses on objects near at hand. If you look at an object some distance off, and then suddenly holding a book before your eyes try to focus on the page, you will find that the print is blurred for a moment before you are able to see. This change of focus is called *accommodation.*

How the eye adapts itself to different intensities of light. — It has been found that different intensities of light in the home are desirable for different kinds of work. The following table gives the intensity in foot candles, which means the amount of light a candle would give at a distance of one foot from an object.

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How does the eye adjust itself to different intensities of light?

Some defects of the eye. — Although the eye is a wonderful piece of mechanism, it has several common defects. Fortunately, due to a study of the eye and of the science called *optics*, we are now able to remedy most of these defects very easily, especially by the use of glasses. It is estimated that one person in every four has some defect in vision. Nearly twenty-five per cent of the school children in Massachusetts and over thirty per cent of the school children in New York have eye trouble of some kind. The most common defect of the eye is *astigmatism*. This is usually due to a slight uneven curvature of the cornea, or the lens. It can easily be discovered by use of the diagram on page 261. Look at either of the figures with one eye closed. If some of the lines appear blurred or thicker than others astigmatism is present and should be corrected with glasses, as this defect is a frequent cause of headache.

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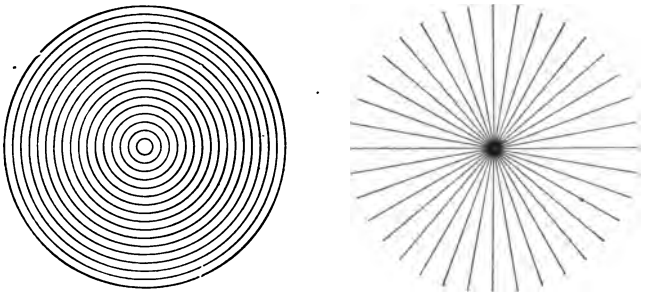

Diagrams to be used in testing for astigmatism.

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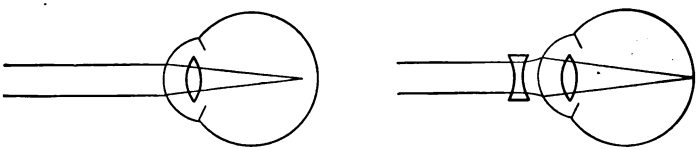
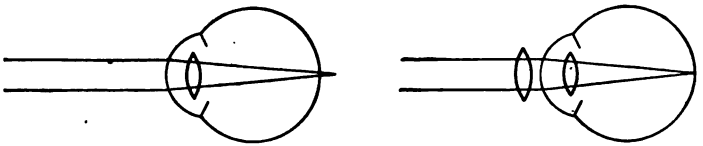


Nearsightedness is remedied by means of concave eyeglass lenses.

Farsightedness is another common defect. In farsightedness, the eyeball is too short, or the lens too thin, and the image if it could be found would fall behind the retina. Hence we get a blur on the retina. This is a more difficult defect to recognize, because people often do not know its presence until they are made aware of it by constant headaches. As a person grows older, he has a tendency to become farsighted. It is frequently the case that elderly persons when reading need one kind of lens, and for ordinary purposes, a second lens. For this purpose a double

glass, called *bifocal*, combining the two lenses in one is often used.



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Testing of eye defects. — A very simple exercise for testing most eye defects is given in the following laboratory experiment.[1]

Experiment. — To test my own eyes for defects.

A. Test for Farsightedness

Method: Using the Snellen test cards, locate the finest line that can be read at a distance of 20 feet. Test each eye separately, covering the eye not in use with a piece of cardboard. Then place a pair of spectacles with a 50 plus diopter lens before the eyes. If as fine or a finer line can now be read, then farsightedness is present and an oculist should be consulted, especially if headaches or other symptoms of eye defects are present. Farsightedness is one of the most frequent causes of eyestrain and is hard to detect because the eyesight seems so good.

How far away can you read these letters? Measure the distance. Twenty feet is a test for the normal eye.

B. Test for Nearsightedness

Method: Use the above-mentioned charts. Determine the finest type you can read at a distance of 20 feet. If it is larger than the 20/20 line, then your vision is defective and you should probably consult an oculist, especially if you have any symptoms of eyestrain.

[1] This test was prepared by Dr. Lucius J. Mason of the Department of Biology, DeWitt Clinton High School, New York.

C. Test for Astigmatism

Method: Use the clock dial disk at 20 feet. If some lines are blacker than others, then astigmatism is present. If headaches or other symptoms are present, then you should consult an oculist and have glasses fitted to correct this trouble.

Eyestrain. — Eyestrain frequently results from attempts to overcome defects of the eye, and also by putting the eyes to too severe use, thus taxing the blood vessels of the eye, and the nerves, which in turn affect the nerves of the head and stomach. The following are some of the things which we often call upon the eye to do:

1. Change focus for different words in the line. This is because they vary in their distance from the eye, and only in two places are the eyes equally distant from the words being read.

2. Insufficient light. The illumination of the object is of extreme importance as the light fades at close of day. For then the white paper of a printed page becomes darker and darker, until finally it reflects very little more light to the eye than the printed letters; consequently the letters no longer stand out, and we have great eyestrain.

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Color blindness. — In order to qualify as an engineer on the trains, or as pilot, where it is necessary to distinguish colors, one must first submit to a test for color blindness.[1] From three to four per cent of boys and about one per cent of girls are color blind. This is one reason why some boys cannot match colors as well as girls can. The most common form of color blindness is the inability to distinguish between red and green.

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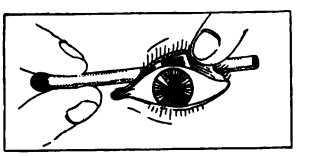

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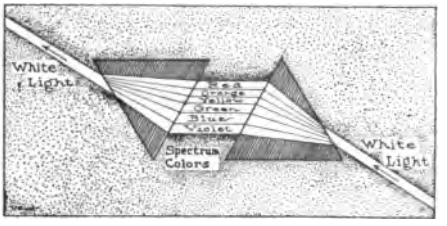
made up of these various colors by passing it through a prism, a triangular shaped glass such as we often see in the candelabra in old houses. If a ray of sunlight were passed through this prism to a screen in a darkened room, we could see all the rainbow colors of the *spectrum*. If we allowed this light to pass through a second prism placed in a reversed direction (see diagram), the colors would again be brought together, and passed out as white light. The rainbow is nothing more or less than light passing through falling drops of water, which act as prisms, thus separating light into its elements, red, orange, yellow, green, blue, and violet.

A prism separates white light into colors of the spectrum.

Structure of the eye. — We are now ready to learn something about the structure of the eye. Our eyes are among the most delicate and wonderful structures in the body. We abuse them constantly, yet they serve us well. Notice how well they are protected by being set in a bony socket, and how admirably the lashes serve to keep out dust and dirt. See, too, how tears flow every time any dust gets upon the delicate membranes of the eye. Also observe, how the



The spectrum colors can be reunited by a second prism so as to produce a beam of white light.

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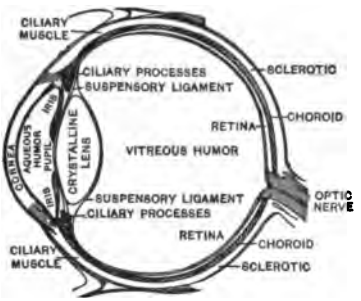

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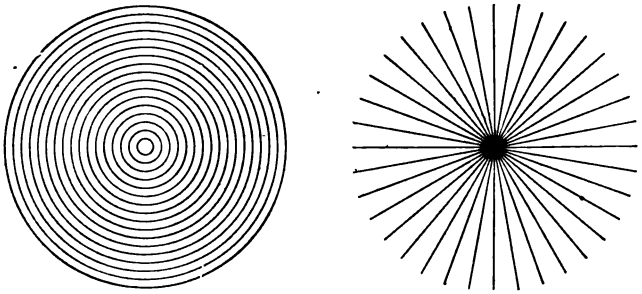

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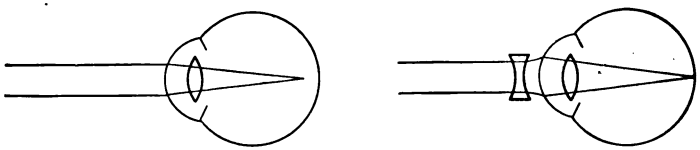

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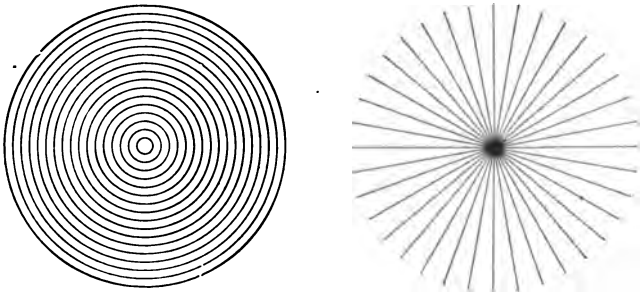

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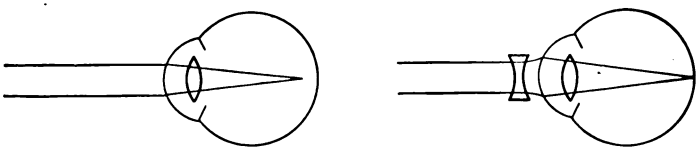

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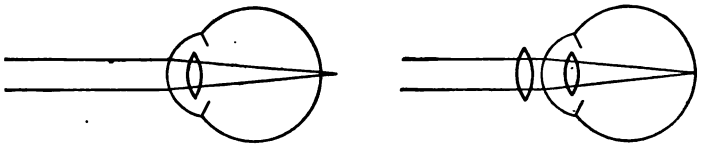

Farsightedness is remedied by means of convex eyeglass lenses.

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A. Test for Farsightedness

Method: Using the Snellen test cards, locate the finest line that can be read at a distance of 20 feet. Test each eye separately, covering the eye not in use with a piece of cardboard. Then place a pair of spectacles with a 50 plus diopter lens before the eyes. If as fine or a finer line can now be read, then farsightedness is present and an oculist should be consulted, especially if headaches or other symptoms of eye defects are present. Farsightedness is one of the most frequent causes of eyestrain and is hard to detect because the eyesight seems so good.

How far away can you read these letters? Measure the distance. Twenty feet is a test for the normal eye.

B. Test for Nearsightedness

Method: Use the above-mentioned charts. Determine the finest type you can read at a distance of 20 feet. If it is larger than the 20/20 line, then your vision is defective and you should probably consult an oculist, especially if you have any symptoms of eyestrain.

[1] This test was prepared by Dr. Lucius J. Mason of the Department of Biology, DeWitt Clinton High School, New York.

C. Test for Astigmatism

Method: Use the clock dial disk at 20 feet. If some lines are blacker than others, then astigmatism is present. If headaches or other symptoms are present, then you should consult an oculist and have glasses fitted to correct this trouble.

Eyestrain. — Eyestrain frequently results from attempts to overcome defects of the eye, and also by putting the eyes to too severe use, thus taxing the blood vessels of the eye, and the nerves, which in turn affect the nerves of the head and stomach. The following are some of the things which we often call upon the eye to do:

1. Change focus for different words in the line. This is because they vary in their distance from the eye, and only in two places are the eyes equally distant from the words being read.

2. Insufficient light. The illumination of the object is of extreme importance as the light fades at close of day. For then the white paper of a printed page becomes darker and darker, until finally it reflects very little more light to the eye than the printed letters; consequently the letters no longer stand out, and we have great eyestrain.

3. The wrong position produces glare. One of the most frequent errors around the home table is that boys and girls frequently face the light rather than allow it to come over the shoulder, or from above. Overhead lighting systems are far better than any light which throws a glare on the paper. Reading in an unsteady or flickering light, particularly on moving trains, is extremely bad for the eye.

4. Too much light in the field of vision is as bad as too little light. For most purposes the student lamp, incandescent electric light, and Welsbach gas light of mod-

erate intensity are preferred to the stronger lights. Fine print and the use of glossy or colored papers are also matters that we should avoid. The use of large type for young children is particularly important, because the eye then is more elastic, and extra strain placed on the muscles of the eye may lead to permanent harm to the curved surfaces.

Color blindness. — In order to qualify as an engineer on the trains, or as pilot, where it is necessary to distinguish colors, one must first submit to a test for color blindness.[1] From three to four per cent of boys and about one per cent of girls are color blind. This is one reason why some boys cannot match colors as well as girls can. The most common form of color blindness is the inability to distinguish between red and green.

Suggestions for the care of the eye. — 1. Do not sit so that direct light reflected from book, paper, or highly polished floors will cause a glare.

2. Do not sit facing strong artificial or natural light.

3. Do not sit so that your shadow falls upon your work.

4. Do not use a flickering light.

5. Do not read on a train or other moving conveyance.

6. Adjust the intensity of the light to your needs. Strong light is needed to read fine print.

7. Do not use the eyes when they ache or when you yourself are fatigued.

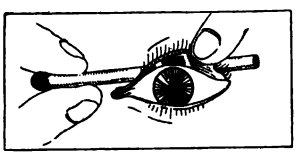
Correction of defects. — If you have discovered from the laboratory exercises that you have eye defects, go at once to an oculist and have glasses to correct them.

If the eyes are red or inflamed or if water runs from them, or if the lids are sore, see a physician at once. Avoid

[1] Holmgren's woolens and Westcott's color slide are useful in detecting color blindness.

doing fine work and reading in bad light. If the eyes pain, use a cloth heated with very hot water. A two per cent boracic acid solution is an excellent wash, and may be used frequently. This, or a salt solution made of one teaspoonful of salt to a pint of boiling water, may be used to wash the eye after getting a cinder in it.

Removal of cinders. — Sometimes particles of dust or cinders get into the eye. These are usually washed out by tears which flow as a result of the irritation. Sometimes, however, they have to be removed. In the case of the lower lid, there is little trouble; if one pulls the lid down the speck can easily be removed with the use of a clean handkerchief. The upper lid is more difficult to pull back. In order to do this successfully, have the person look downward, place a small pencil against the upper portion of the lid, take hold of the eyelashes, turn the lid upward and back over the pencil, and the lid is in such a position that the speck can easily be located. Sometimes a tiny sharp-pointed bit of glass or cinder becomes embedded in the surface of the cornea. A drop of olive oil in the eye prevents irritation until with the help of an expert physician it can be removed.

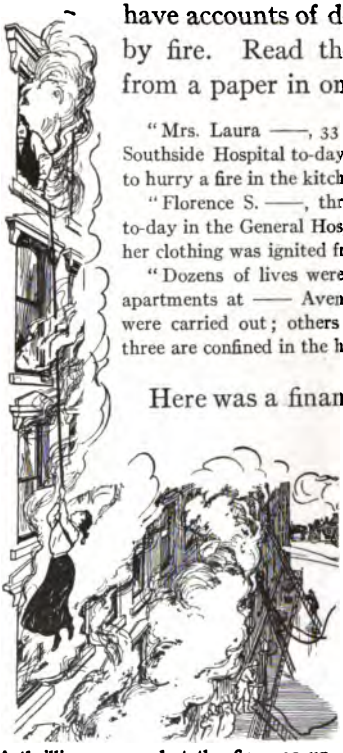


Turning the eyelid back to remove dirt.

REFERENCE BOOKS

Allen, *Civics and Health* (For teachers), Chapter VII. Ginn and Company.
Brownell, *General Science*, Chapter I. Blakiston's Son and Company.
Clark, *Introduction to Science*, Chapters XXVI, XXVIII, XXIX. American Book Company.
Hodgdon, *Elementary General Science*, Chapter X. Hinds, Hayden, and Eldredge.
Hunter, *A Civic Biology*, Chapter XXIII. American Book Company.

Fire and its dangers. — You may have been fortunate enough never to have lost your home or loved ones through fire, but nevertheless that danger is always with us. It stands ready for the careless moment when you give it an opportunity to burst forth with its suffocating and deadly flames, and many are its victims. Every week the papers have accounts of destruction and suffering caused by fire. Read the following clippings selected from a paper in one week:



"Mrs. Laura ——, 33 years old, of 66 —— Street, died in the Southside Hospital to-day from burns suffered when she attempted to hurry a fire in the kitchen stove by pouring oil over it."

"Florence S. ——, three years old, of —— Avenue, died early to-day in the General Hospital from burns received yesterday, when her clothing was ignited from a firecracker."

"Dozens of lives were imperiled in a fire which destroyed the apartments at —— Avenue early this morning. Some occupants were carried out; others jumped from the second story window; three are confined in the hospital. The damage was $4000."

Here was a financial loss great enough to ha bought each one of you in class two bicycles, a pa skates, skis, and a goo

"Fire which threatened to big section of Homestead ca of upwards of $45,000. H ried sparks and several started. Fires were o after aid arrived fro oughs."

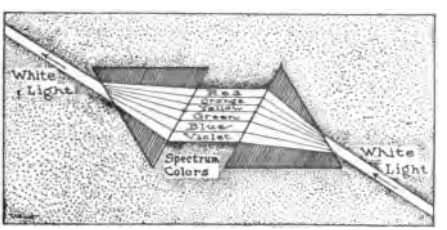
A thrilling rescue, but the fire was unnecessary. (After Richman.)

The mon would hav of the pupils in your class an auto of fires which have occurred in the in the last twenty-four hours coul

made up of these various colors by passing it through a prism, a triangular shaped glass such as we often see in the candelabra in old houses. If a ray of sunlight were passed through this prism to a screen in a darkened room, we could see all the rainbow colors of the *spectrum*. If we allowed this light to pass through a second prism placed in a reversed direction (see diagram), the colors would again be brought together, and passed out as white light. The rainbow is nothing more or less than light passing through falling drops of water, which act as prisms, thus separating light into its elements, red, orange, yellow, green, blue, and violet.

A prism separates white light into colors of the spectrum.

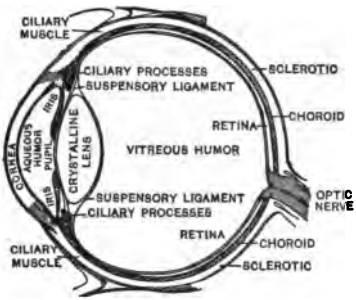
Structure of the eye. — We are now ready to learn something about the structure of the eye. Our eyes are among the most delicate and wonderful structures in the body. We abuse them constantly, yet they serve us well. Notice how well they are protected by being set in a bony socket, and how admirably the lashes serve to keep out dust and dirt. See, too, how tears flow every time any dust gets upon the delicate membranes of the eye. Also observe, how the



The spectrum colors can be reunited by a second prism so as to produce a beam of white light.

eye can be turned in different directions, due to the little paired muscles which serve to move the eyeball.

If we study a section as shown, by cutting the eyeball in halves from front to back, we find that it is more like the camera than it is on the surface. In the front there is a transparent lens which makes a little picture at the back of the eye, just as the camera lens makes a picture. This lens, however, is not fixed in shape like that of a camera, but is flexible, and is made thicker or thinner by movement of delicate muscles, thus doing away with the necessity of moving the lens forward or backward in order to get a picture in focus.



Section of the eye. Find the parts which correspond to those in a camera.

The main portion of the eye is filled with a colorless substance, the *vitreous humor*, while back of this lies a pigmented receiving organ connected by nerves with the brain, known as the *retina*. It is on this sensitive surface that our images are received and sent to the brain by the optic nerve, so that we really see in the brain, although the picture is received on the retina. There are three coats covering the eyeball, a tough outer coat, the *sclerotic*, a middle coat, the *choroid*, while the inner coat is the *retina*. These coats are open at the front, and the choroid, which is filled with *pigment*, or color-bearing material, makes a kind of curtain. It is this curtain, called the *iris*, which gives the color to a person's eye. The iris controls the amount of light which passes through the hole, or *pupil*,

into the inside of the eye, just as the diaphragm in the camera controls the light. On a bright day, would you expect the pupil of the eye to be larger or smaller than on a dull day? Why?

Experiment. — To see the pupil of the eye change in size.

From a room in which all the other windows are darkened look out of the window into a very bright sky for a moment. Examine the eye in a mirror. Then turn quickly and look at your eyes in the mirror with your back to the light. Result? Explain.

Control of focusing. — The eye adjusts itself quickly to see objects at different distances. This is done by means of tiny muscles called the *ciliary* muscles, which change the thickness of the lens. A flat lens focuses well on distant objects, while a thick lens focuses on objects near at hand. If you look at an object some distance off, and then suddenly holding a book before your eyes try to focus on the page, you will find that the print is blurred for a moment before you are able to see. This change of focus is called *accommodation*.

How the eye adapts itself to different intensities of light. — It has been found that different intensities of light in the home are desirable for different kinds of work. The following table gives the intensity in foot candles, which means the amount of light a candle would give at a distance of one foot from an object.

	Desirable at Times	Minimum
Hall and stairways . .	1 — 2.5 foot candles	0.5 foot candle
Living room and dining room	3 — 6 foot candles	1.5 foot candles
Sewing room	6 — 12 foot candles	3. foot candles

The eye is able to adjust itself to different amounts of light, within rather wide limits, without harm. In order to avoid straining the eye, it is necessary to have enough light. Much harm is sometimes done when we are young by trying to read in insufficient light; just as much harm has been done by looking into a blinding light, or trying to look at the sun, as some youngsters do at times to " stunt " each other.

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Some defects of the eye. — Although the eye is a wonderful piece of mechanism, it has several common defects. Fortunately, due to a study of the eye and of the science called *optics*, we are now able to remedy most of these defects very easily, especially by the use of glasses. It is estimated that one person in every four has some defect in vision. Nearly twenty-five per cent of the school children in Massachusetts and over thirty per cent of the school children in New York have eye trouble of some kind. The most common defect of the eye is *astigmatism*. This is usually due to a slight uneven curvature of the cornea, or the lens. It can easily be discovered by use of the diagram on page 261. Look at either of the figures with one eye closed. If some of the lines appear blurred or thicker than others astigmatism is present and should be corrected with glasses, as this defect is a frequent cause of headache.

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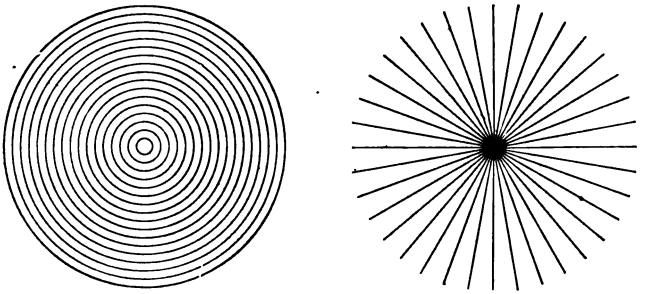

Diagrams to be used in testing for astigmatism.

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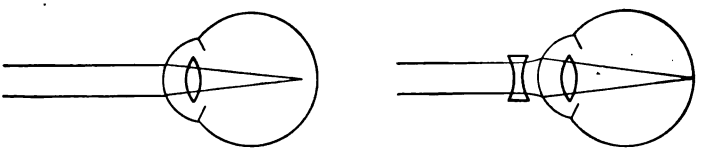

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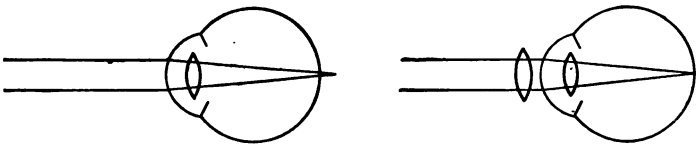

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A. Test for Farsightedness

Method: Using the Snellen test cards, locate the finest line that can be read at a distance of 20 feet. Test each eye separately, covering the eye not in use with a piece of cardboard. Then place a pair of spectacles with a 50 plus diopter lens before the eyes. If as fine or a finer line can now be read, then farsightedness is present and an oculist should be consulted, especially if headaches or other symptoms of eye defects are present. Farsightedness is one of the most frequent causes of eyestrain and is hard to detect because the eyesight seems so good.

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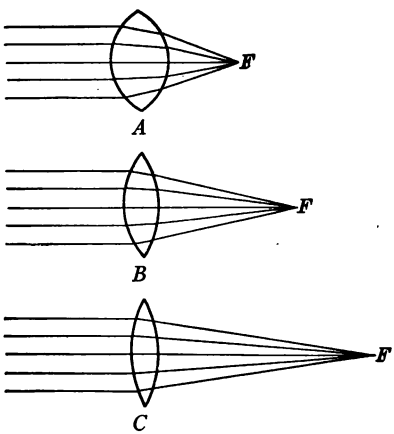
4. Too much light in the field of vision is as bad as too little light. For most purposes the student lamp, incandescent electric light, and Welsbach gas light of mod-

should we abuse these delicate organs we call the eyes? The daytime is not long enough for us, so we provide ourselves with artificial light and keep our eyes at work part of the night. We read fine print in dim light, and injure our eyes in a hundred ways. Our eyes are of so much importance to us that it seems wise to devote an entire chapter to them and their care.

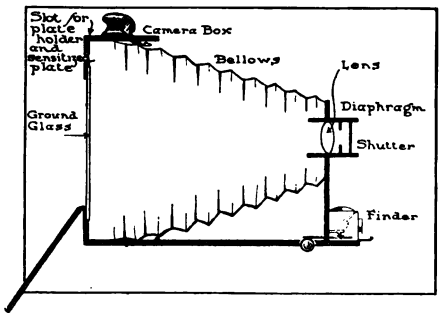
Lenses and what they do. — We have all tried to set fire to a pile of leaves or paper with a burning glass. An ordinary reading glass found sometimes on the library table is a common example of a simple lens. If we look at it in cross section, we find that it bulges outward in the middle in both directions. We call such a lens *double convex*. If we hold such a lens so that the sun shines through it, and move a piece of paper toward or away from it, one place will be found where only a tiny spot will be lighted, but this will be extremely bright, and enough heat may be concentrated to set the paper on fire. This point at which the sun's rays have been brought together (see *F* in figure) is called the *focus*. When light passes through the air to the glass, it moves in parallel rays, but the glass bends the rays so that they come together at one point. This point is called the *principal focus* of the



Which lens has the shortest and which the longest focal length?

lens, and the distance from that point to the center of the lens is called the *focal length.* You can easily measure the focal length of a lens by this method.

The camera. — The study of a camera will help us to understand the parts of the eye. If we carefully note the parts of the camera shown in the illustration, we find that it is a light-tight box painted black on the inside to absorb all light rays, and having a lens, a diaphragm for changing the size of the opening, and a shutter in front which controls the time of the exposure of the photographic plate or film which is placed at the opposite end of the camera. In a photographer's camera, such as is shown in the illustration, a ground glass is placed at the end where the plate is held when an exposure is made.



Essential parts of a plate camera.

Experiment. — To show how a lens is used in focusing

Materials: Double convex lens. White screen. Large carbon bulb.

1. Focal length.

Hold a double convex lens in sunlight at right angles to the rays. Place a screen of white paper back of the lens. Adjust the distance between them until the spot of light (the sun's image) is the smallest. Measure the distance from the lens to the screen. This distance is called the *focal length* of the lens.

Compare the focal length of a thick lens with that of a thin lens by this method.

2. Focusing as done in the camera.

Hold a double convex lens about three times its focal length from a large carbon lamp which is lighted in a dark room. Move a screen of

A = 1 lb. Sodium Nitrate
B = 1 lb. Potassium Sulphate
C = 2 lb. Acid Phosphate

On plots 1, 4, and 7, use no fertilizer whatever; on plot 2, use A, B, C; on 3, use B and C; on 5, use A and B; on 6, use A and C. Plant same amount of seeds on each plot; give all same care. Compare crops from each plot to decide the fertilizer most needed by the soil for that particular crop.

NO FERTILIZER	1
A, B AND C	2
B AND C	3
NO FERTILIZER	4
A AND B	5
A AND C	6
NO FERTILIZER	7

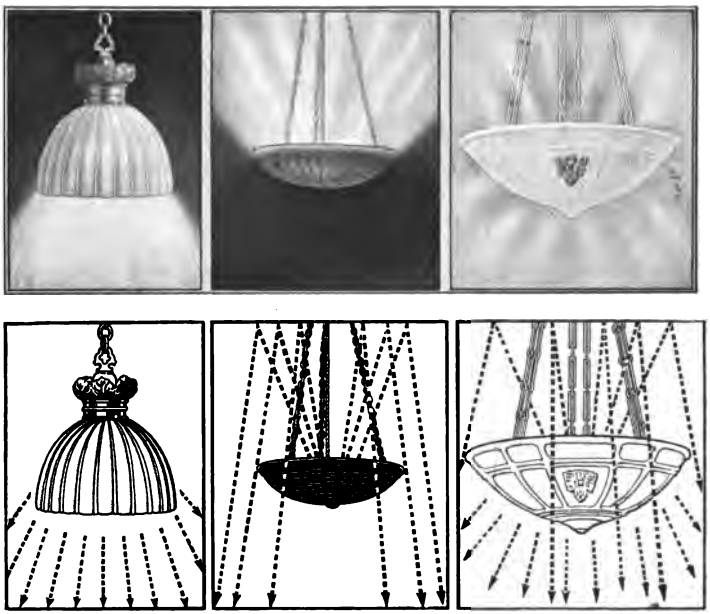
Suggested Projects.

1. To plan, plant, and take care of the vegetable garden.
2. To make and use a hotbed or a cold frame.
3. Make a collection of different types of soils found in your neighborhood, keeping a record of the kind of vegetation or lack of plant life found in each locality.

Science and the home garden. — "What do I want to know about science in taking care of my home garden?" — might be the remark of a boy who has had some gardening experience. He has grown vegetables and flowers without any more knowledge than the common sense that he has picked up from older people or read in books or garden magazines. It is true that a person might have a flourishing garden and know very little about the scientific principles necessary to understand the soil and the life of the plants living in it. But when we consider that plants are living things, that they require certain "plant foods" or raw food materials, and that they must be provided with what they most require in order to grow to their

TABLE OF INTENSITIES OF COMMON TYPES OF LIGHTING

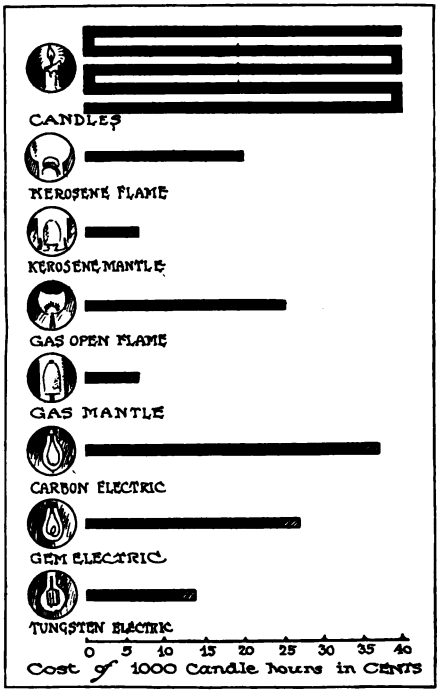
The common carbon incandescent lamp	16 candle power
The small tungsten incandescent lamp	20 " "
The fishtail gas flame	22 " "
The Welsbach gas flame	60 " "
A 100-watt tungsten incandescent	92 " "



Explain how these pictures illustrate *direct*, *indirect*, and *semi-indirect* lighting.

Methods of lighting. — Several ways of lighting by electricity are now in use. In *direct lighting*, the light is thrown directly from the lamp or by a reflector to the place where it is used. This produces a glare in some directions and has some disadvantages which we shall study in connection with the eye. Direct lighting is economical because little light is lost through diffusion or absorption.

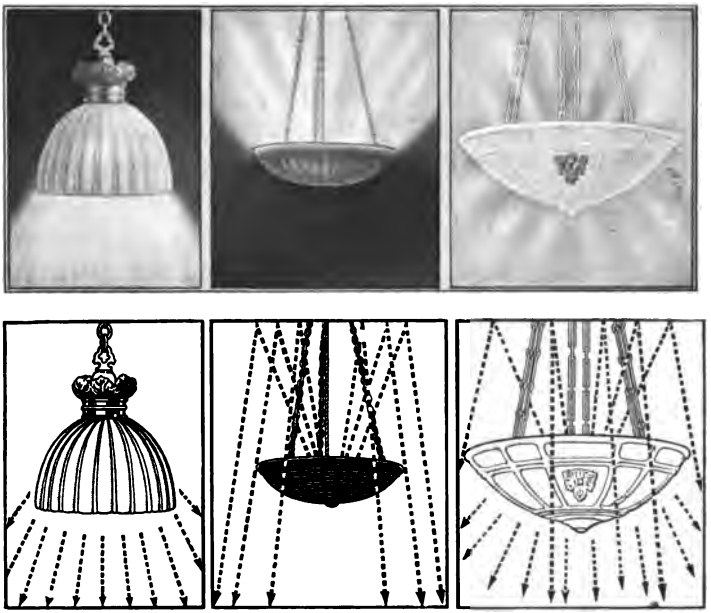
The tungsten light. — The old carbon filament is rapidly being replaced by the tungsten lamp. The carbon filament can be heated to 1850 degrees Centigrade, while the tungsten filament can be heated to 2100 degrees Centigrade, and in bulbs which are filled with nitrogen, the temperature may go still higher; therefore we get a much brighter light from the tungsten lamp. A one hundred candle power tungsten, nitrogen-filled bulb requires only about one seventh as much electricity as the one hundred candle power carbon lamp. The table on the following page shows some common light intensities. A good home project would be to find out the difference in the cost of lighting your home with the fishtail gas flame, the Welsbach gas flame, carbon filament electric lights, and tungsten filament lights.



This chart, suggested by the Bureau of Standards, shows the relative cost of light from different illuminants, based on the following prices: candles, 12¢ a pound; kerosene, 15¢ a gallon; gas, $1 per 1000 cu. ft.; electricity, 10¢ per kilowatt-hour. Solid black represents cost of fuel, and shaded, cost of mantles and bulbs. Revise this chart in your notebook to agree with cost of these illuminants in your own city or town.

TABLE OF INTENSITIES OF COMMON TYPES OF LIGHTING

The common carbon incandescent lamp	16 candle power
The small tungsten incandescent lamp	20 " "
The fishtail gas flame	22 " "
The Welsbach gas flame	60 " "
A 100-watt tungsten incandescent	92 " "



Explain how these pictures illustrate *direct*, *indirect*, and *semi-indirect* lighting.

Methods of lighting. — Several ways of lighting by electricity are now in use. In *direct lighting*, the light is thrown directly from the lamp or by a reflector to the place where it is used. This produces a glare in some directions and has some disadvantages which we shall study in connection with the eye. Direct lighting is economical because little light is lost through diffusion or absorption.

In *indirect lighting*, an opaque reflector comes between the eye and the bulb and all light is directed upward to a white or light colored ceiling. Here the light is diffused, and this resembles daylight in its general effect. It is not economical, but is pleasant and restful for the eyes. In *semi-indirect lighting*, a translucent reflector throws most of the light to the ceiling. Some light passes through the shade. There is no glare in this system, and its cost is intermediate between the other two systems.

Use of the score card. — Here the boy and girl in the country will probably have the advantage in natural lighting, but the city child will perhaps have better conveniences in artificial light. Study carefully to find out the relative cost of your lighting system and make inquiries as to the cost of light in your town, if you have gas or electricity. What improvement in your home lighting can you suggest?

SCORE CARD. LIGHTING MY HOME

				My Score	
					Total
SUNLIGHT	Three fourths of all rooms have direct sunlight (4)	Half rooms have direct sunlight (2)	No rooms have direct sunlight (0)	....	
	All rooms well lighted by natural light. No artificial light needed until after sundown (2)	Half rooms well lighted by natural light; no artificial light needed until after sundown (1)	No rooms in which artificial light is not needed before sundown (0)	....	
	Home not directly shaded by trees or other buildings (2)	House partly shaded (1)	House densely shaded (0)	....	
	Well-lighted airy cellar (2)	Cellar not light but airy (1)	Cellar dark and musty (0)	....	....
WINDOWS AND WALL PAPER	Window space at least $\frac{1}{4}$ floor space (av. all rooms) (4)	Window space at least $\frac{1}{5}$ floor space (2)	Window space less than $\frac{1}{6}$ floor space (0)	....	

SCORE CARD. LIGHTING MY HOME — *Continued*

				My Score	
					Total
WINDOWS AND WALL PAPER	Awnings or shutters provided (2)	Shutters, no awnings (1)	No shutters or awnings (0)	....	
	No dark hangings at windows (2)	Dark hangings at some windows (1)	Dark hangings at most windows (0)	....	
	No rooms having dark wall papers (2)	One half rooms having dark papers (1)	Three fourths rooms having dark wall paper (0)	....	....
COST OF ARTIFICIAL LIGHTING	Economical (Consult tables, page 245, and diagram, page 248) (10)	Moderately economical (5)	Expensive (0)	....	....
PROPER LIGHTING FOR ALL KINDS OF WORK	Light used gives no glare and does not shine in eyes when reading or at dining table (2)	Sometimes direct light in eyes (1)	Usually direct light in eyes (0)	....	
	Strong light for sewing (2)	Fair light for sewing (1)	Poor light for sewing (0)	....	
	Kitchen well lighted (2)	Good light at sink or range, not at both (1)	Poor light all parts of kitchen (0)		
	Lights both sides of mirror in bathroom (2)	Light on one side bath mirror (1)	No light near bathroom mirror (0)	....	
	No carrying of lights from one part of the house to another (2)	Necessary to carry light to some parts of the house (1)	Always necessary to carry light from one room to another or to light with matches (0)	....	....
CONVENIENCE OF LIGHTING SYSTEM	Gas or electric wall switches (2)	Gas or electric control at jet or socket (1)	Oil lamps used (0)	....	
	Switch on one floor turns on light on other floors (2)	Switch control of light upstairs and down but not to cellar (1)	No switch control from different floors (0)	....	
	Either floor sockets for electric connection or extra gas connection for small heater or gas iron (2)	Some, but insufficient extra connections (1)	No extra connections (0)	....	
	Different amounts of light easily obtained in most rooms (2)	Variation of light intensity possible in only a few rooms (1)	Variation of light difficult in any room (0)		
	Lighting service never interrupted (2)	Service occasionally interrupted (1)	Service frequently interrupted (0)	....	....
GRAND TOTAL			PERFECT SCORE 50		

outer portions of the roots of most plants are provided with these little structures, so that water is constantly being taken by absorption. Since plants pass off many times their own weight of water by evaporation through their leaves during the growing season, the root hairs must have a very considerable work to do. We shall not try to show now how they take the water in. It is sufficient to know that water with its soluble mineral salts passes from these root hairs up through the roots and stems to the leaves where, as we shall see, it is used in making living matter and food for the plant.

The root hairs take more than water out of the soil. — If a root possessing root hairs is washed carefully, it will be found to have little particles of soil still clinging to it. These particles of soil seem to be cemented to the sticky surface of the root hair. Root hairs give off an acid. Sometimes soils become too acid. Lime added to such soils helps to neutralize the acid and make them fit for garden use. Acids in the soil help dissolve some of the mineral substances. The resulting solutions mixed with soil water are absorbed by the root hairs. There is also much mineral matter from the soil dissolved in water without the aid of the acid, which is taken up by the root hairs.

Plants take nitrogen from the soil. — One very necessary element in the composition of living matter is nitrogen. Nitrogen makes up nearly four fifths of the air around us, and yet it is not available for use by plants until certain bacteria in the soil have acted on it. Some of these bacteria live in little *nodules* or lumps on the roots of clovers, peas, beans, and other plants called *legumes* and have the power in some mysterious way to take some of this nitrogen out of the air and fix it so that it

This gives good distribution of light within the room. If a room is too light, and at the same time too hot in summer, we can adjust the amount of light entering by means of blinds or awnings. The Venetian blind or porch shade is a convenient type to use, for it shuts out the sun's rays without preventing a circulation of air.

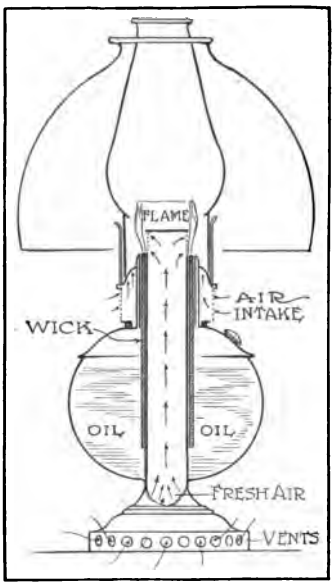
Both these rooms receive the same amount of light. One has dark wall paper and the other light.

Artificial light in our homes. — It was not so many years ago that candles were the sole source of light in our homes, and at the present time, candle light lends a pleasant glow to birthday and Christmas parties. Up to the time of the Civil War, tallow candles, pine knots, and heavy oils were common sources of light for reading. People to-day use eighteen times as much light as they did one hundred fifty years ago, and at one third the cost.

The first gas plant in America was started at Philadelphia in 1815. Then candles cost two and one-half cents each and would burn for seven hours. About the middle of the nineteenth century the whaling industry was at its height, and sperm oil was burned in lamps. Petroleum was first used in 1858 for lighting purposes, and so rapidly did its use grow that in 1860, two million barrels were produced, and to-day, almost three hundred million barrels a year. Although artificial gas was slow in its introduction, yet it now plays a very important part in the lighting of our

houses. About 1890, electricity began to come into general use for lighting purposes, and is now one of our best known servants in the home.

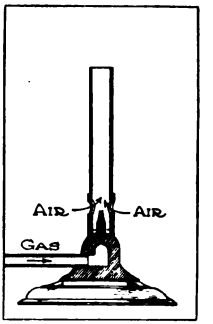
Kerosene light. — Kerosene oil lighting is still one of the common methods of illumination, especially in country homes. When oil first came into use, it burned with a smoky flame, until in 1783, Argand, a Swiss physician, made a ring-shaped wick with a central draft. This allowed convection currents to be set up inside the wick, and thus a larger flame could be fed with oxygen. Flat wick lamps which give smokeless flames are now in common use, but the central draft lamp gives more light. The gasoline lamp and acetylene lamp, although used in many places, are not in sufficiently common use to warrant a full description here.



Central-draft oil lamp.

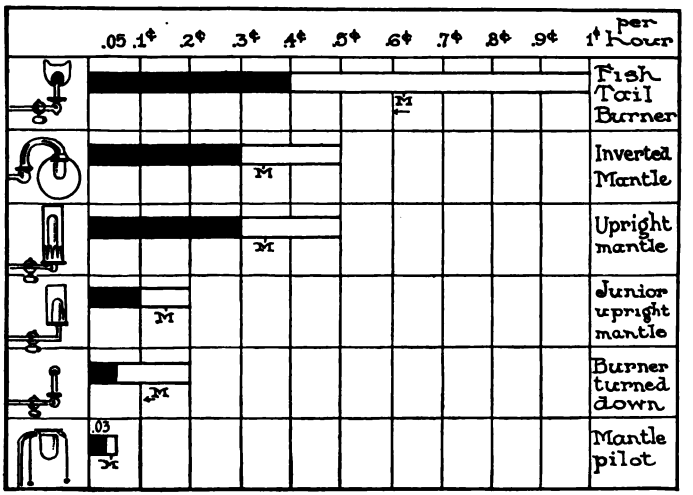
Gas in the home. — Although not all of us are fortunate enough to have either natural or artificial gas in the home, yet we should know something about the gas burner and its uses. When a candle burns, as we know, the paraffin wax melts, becomes a vapor, and burns. You can prove that the gas inside of the candle flame is not on fire by passing a small tube into it, leading out the gas, and then lighting it. When gas, passing from the outlet of an ordi-

nary burner, has not been previously mixed with air, a yellow flame results. This is a very wasteful type of burner. The Bunsen burner, in which air is mixed with the gas, gives a clean hot flame which is not very luminous. A combination of this type of burner, which produces much heat, with a mantle which glows when heated, gives us the Welsbach light. Welsbach mantles are made from compounds of two rare metals, thorium and cerium, which when heated to a high temperature give the bright light we are so familiar with.



A Bunsen burner.

Experiment.—To show the advantage of the mantle in gas lighting. Connect a common fishtail burner and a Thorp gauge to the gas supply. Light the burner and see how many cubic feet of gas per hour are



Effect of gas appliance on cost of gas. Black = minimum; Black and white = maximum; M = mean cost per hour.

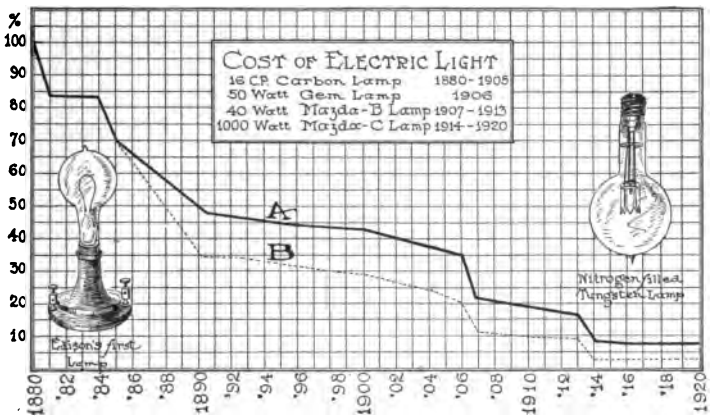
registered. Replacing the fishtail burner by a mantle and burner, how does the light produced in the two cases compare? How much gas is being consumed in the latter case? What is your conclusion? (If a Thorp gauge is not available, test the gas consumed in a specified time by observing the small indicator of the gas meter dial.)

The first electric lamp. — It is due to Thomas Edison that we have the incandescent light. The story of its invention is well known. He worked for a great many years and spent hundreds of thousands of dollars in the perfection of the bulb light, patented in 1880, which he furnished finally with a carbon filament, made of bamboo. The way in which this filament gives light can be explained better after we have performed an experiment to illustrate what makes electricity give light. Electricity is a form of energy which is conducted easily by metals. We have all seen that the pipe conducting liquids in the house offers resistance to them so that they do not flow so easily. In somewhat the same way wires offer resistance to electricity. That part of the electrical energy used in overcoming this resistance to the wire conductor is changed into heat, which when intense enough produces light. This may be shown by the following experiment:

The carbon filament incandescent lamp and the modern tungsten lamp.

Experiment. — To show how electricity may be changed into light. (To be performed by the teacher.)

Suspend a ten-foot length of fine iron wire (No. 26) from insulated supports. Fasten one wire of a 110-volt circuit to one end of the iron wire, and bring the other end of this circuit in contact with the other end of the wire. Move the end of the circuit wire along, shortening the length of the iron wire until it becomes red hot. All this heat energy is produced at the expense of electrical energy. As the wire is shortened the heat increases. The hotter the wire, the greater per cent of electrical energy is changed to heat.



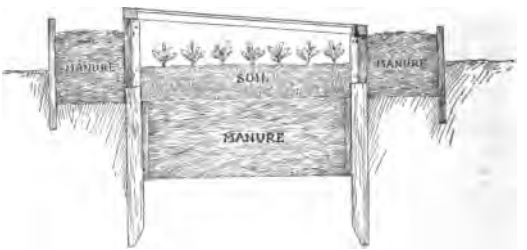
Graph showing decrease in cost of electric lighting in forty years. A is the reduction due to lamp improvement only; B, due to lamp improvement and reduced rates for current.

We thus see from the result of this experiment that it is more economical to use electric bulbs which contain filaments which can be raised to high temperatures. Why?

Experiment. — To show the advantage of tungsten over carbon lamps. Connect one or more small carbon lamps in a circuit with a kilowatt-hour meter. Find the electrical energy used in running these lamps for a definite time, say one hour. Replace the lamps by an equal number of small tungsten lamps (25 watt), and find the electrical energy consumed during an equal interval of time.

Each carbon lamp gives 16 candle power, and each tungsten lamp gives 20 candle power. Reckoned on the basis of candle power, what is the ratio of cost of running the two types of lamps?

ing a bed three feet deep. The lower part is filled with manure, which is allowed to heat and then is reopened, being tested from day to day until it comes to a temperature of eighty degrees Fahrenheit. Cucumbers, lettuce, muskmelons, and tomatoes may be started in the hotbed, and later transferred to the outside. To have the hotbed work successfully, it should be banked on the outside



Cross section of a hotbed. (After Moore and Halligan.)

with manure in order to keep the heat in, and remember to cover it at night in cold weather with old rugs or mats in addition to the sash. The table on the next page gives some useful information for planting your own garden.

Score card of my home garden. — It is not in the country alone that school gardens flourish. Very many city boys and girls have an opportunity to compete with country boys and girls in the home garden project. It will interest you all to know that if you score high in this project you ought to belong to the United States School Garden Army. Perhaps you do — and perhaps you have already received an award from them. If not, why not try for it next summer? The note found under the title of the score card will give you the address to which you may write for directions.

PLANTING AND SEED TABLE FOR VEGETABLES FOR THE HOME GARDEN

From Bulletin, "The Home Vegetable Garden," by C. W. Waid, Michigan Agricultural College.

Name of Vegetable	Date of Planting: [1] Seeds, first crop; [2] Plants, first crop	Depth of Planting (inches)	Distance Apart of Rows (feet)	Distance Apart of Rows (inches): Hand cultivation	Distance Apart of Plants in Rows (inches): Hills	Distance Apart of Plants in Rows (inches): Drills	Ready to Use After Planting (days)
Beans, bush	[1]May	1–2	2½–3	18–30	8–12	3–4	45–65
Beans, pole	[1]May 15–31	1–2	3–4	24–36	18–30	5–6	50–80
Beets	[1]April 15–30	½–¾	2½–3	18–24	.....	2–3	60–85
Brussels sprouts	[2]May	.....	2½–3	18–30	18–24	.....	95–120
Cabbage, early	[2]April 15–30	.....	2½–3	18–30	12–18	.....	90–105
Cabbage, late	[2]May	.....	2½–3	18–30	18–24	.....	100–150
Carrots	[1]May	½–¾	2–2½	18–24	.....	3–4	75–110
Cauliflower	[2]May	.....	2½–3	18–30	18–24	.....	100–130
Celery, early	[2]April 15–30	.....	2½–5	18–30	.....	4–5	120–130
Celery, late	.....	.....	3–5	18–60	.....	5–6	130–150
Corn, early	[1]May 1–15	1–1½	2½–3	24–36	18–24	8–10	65–90
Corn, late	[1]May 15–31	1–1½	2½–3	24–36	24–36	10–12	75–100
Cucumbers	[1]May 15–31	¾–1	4–6	48–60	48–60	12–18	60–80
Eggplant	[2]May 20–31	.....	3–4	24–36	24–36	.....	150–160
Endive	[2]April 20–30	½–¾	2½–3	12–18	.....	12–18	90–130
Kale	[1]May	½–¾	2½–3	18–30	.....	8–15	90–120
Kohl-rabi	[2]May 1–15	.....	2½–3	18–30	12–18	6–8	60–80
Lettuce	[1]April 15–30	½–½	2½–3	12–18	.....	4–12	60–90
Muskmelon	[1]May 15–31	–1	4–6	48–60	48–60	12–18	120–150
Okra	[2]May 15–31	.....	2½–3	18–30	18–30	.....	.....
Onion, sets	[1]April 15–30	½–¾	2½–3	12–18	.....	2–3	25–50
Onion, seeds	[1]May	¼–½	2½–3	12–18	.....	1½–2	130–150
Parsley	[1]April 15–30	½–¾	2½–3	12–18	.....	6–10	90–120
Parsnips	[1]May	½–¾	2½–3	18–24	.....	3–4	125–160
Peas, early	[1]April 15–30	1–2	2½–3	18–30	.....	Drilled	40–80
Peas, late	[1]May 1–15	1–2	2½–3	24–36	.....	Drilled	65–90
Peppers	[2]May 15–31	.....	2½–3	18–30	15–18	.....	100–140
Potatoes, early	[1]April 15–30	2–3	2½–3	18–30	9–15	.....	80–100
Potatoes, late	[1]May	4–5	2½–3	24–30	12–18	.....	100–140
Pumpkins	[1]May 15–31	1–1½	6–10	72–96	72–96	.....	100–140
Radishes, early	[1]April 15–30	½–¾	2½–3	12–18	.....	Drilled	30–40
Radishes, medium	[1]May	½–¾	2½–3	12–18	.....	Drilled	35–50
Rutabaga	[1]April 15–30	½–¾	2½–3	18–24	.....	6–10	75–100
Salsify	[1]May 1–15	½–¾	2½–3	18–24	.....	3–4	120–180
Spinach	[1]April 15–30	½–¾	2½–3	18–24	.....	4–6	30–60
Squash	[1]May 15–31	1–1½	3–8	36–96	36–84	.....	60–125
Sweet potatoes	[2]May 15–31	.....	2½–3	24–36	.....	14–18	120–130
Tomatoes	[2]May 15–31	.....	3–5	24–36	18–36	.....	100–140
Turnips	[1]April 15–30	½–¾	2½–3	18–24	.....	4–6	60–80
Watermelons	[1]May 15–31	¾–1	6–8	60–72	60–72	.....	100–150

SCORE CARD. MY HOME GARDEN [1]

	Score	
	Perfect Score	My Score
General appearance	2	
Arrangements of rows	3	
Freedom from weeds	3	
Cultivation and care	2	
Choice of vegetables		
For home use	5	
For canning	5	
Freedom from pests		
Spraying for insects or disease when needed	5	
Other remedial measures if needed	5	
Evidences of		
Continuous cultivation	3	
Crop rotation	2	
Care of tools	5	
Value of produce		
Used at home	4	
Sold in the market	2	
Used for canning	2	
Accuracy of garden records	2	
TOTAL	50	

REFERENCE BOOKS

Duncan, *Home Vegetables and Home Fruits* (For garden project). Charles Scribner's Sons.

Corbett, *The School Garden*, U. S. Dept. Agriculture, Bulletin 218, also Farmers' Bulletins 154, 255, 408.

Garden Manual, U. S. School Garden Army, Bureau of Education, Washington, D. C.

Food Supply in Families of Limited Means. League for Preventive Work, Boston, 1917.

[1] Modified from General Leaflet No. 10, United States School Garden Army, Bureau of Education, Washington, D. C.

Hunter, *A Civic Biology*, Chapters VI, VII. American Book Company.

Hunter, *Laboratory Problems in Civic Biology*, Chapters VI, VII. American Book Company.

Jackson and Daugherty, *Agriculture through Laboratory and School Gardens*. Orange Judd Company, N. Y.

King, *The Soil* (For teachers). The Macmillan Company.

Lyon, *Soils and Fertilizers* (For teachers). The Macmillan Company.

Mayne and Hatch, *High School Agriculture*, Chapter II. American Book Company.

Moore and Halligan, *Plant Production*, Chapter XIII. American Book Company.

Rexford, *The A B C of Gardening* (Flower gardens). Harper and Brothers.

Spellman, *Farm Science*, Chapter IV. World Book Company.

Trafton, *Science of Home and Community*. The Macmillan Company.

Transeau, *Science of Plant Life*, Chapter IV. World Book Company.

The Small Vegetable Garden, U. S. Dept. Agriculture, Farmers' Bulletin 818.

U. S. Food Administration, *Food and the War*, Chapter XIII. Houghton Mifflin Company.

War Garden and the Storage of Vegetables, Victory Edition 1919. National War Garden Committee, Washington, D. C.

CHAPTER XX

PLANT FRIENDS AND PLANT PESTS

Problems. — 1. *To learn something about the work of microörganisms in the soil.*

2. *To discover how fungi injure plants.*

3. *To know the life history of common insect pests.*

4. *To find out something of the value of birds to our gardens.*

5. *To learn how to safeguard the garden against ravages of pests.*

Experiments and demonstrations. — 1. To show the life history of a moth and a butterfly.

2. To learn to recognize insects that frequent flowering or garden plants.

3. To illustrate the proper way of making some insecticides, fungicides, and sprays.

Project I. — To ELIMINATE THE PLANT PESTS FROM MY HOME GROUNDS.

1. Learn the habits and something of the life history of the pests which appear.

2. Learn what pests are most likely to attack each kind of plant on the grounds.

3. Learn when to apply sprays most effectively and about other devices that may be used to prevent or destroy the pests.

4. Learn how to prepare and to apply the sprays, etc.

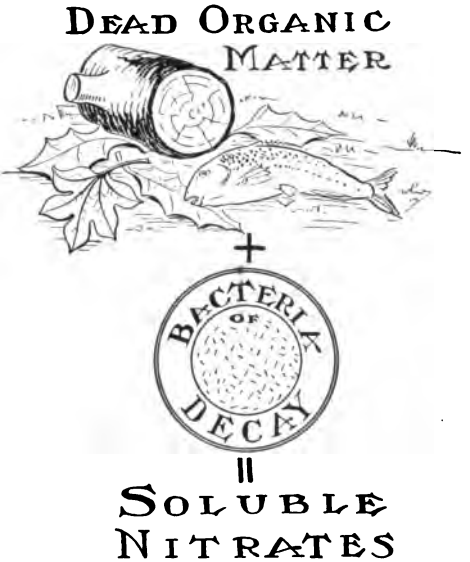
5. Report all your efforts in fighting plant pests through an entire summer, showing to what extent your garden benefited.

Suggested Projects.

1. TO ATTRACT AND PROTECT HELPFUL BIRDS.

2. TO MAKE A COLLECTION OF INSECTS AND CLASSIFY THEM, MAKING AT LEAST ONE EXHIBIT FROM EACH OF THE IMPORTANT ORDERS.

The living things in the soil. — Life in this world consists of a great deal of give and take. We could not get along comfortably at home without giving in to our brothers and sisters, and without helping mother and father, for we take so much in return from them. In the plant and animal world similar conditions exist. Plants could not get along without dead organic matter. We have seen the need of manure and other decayed materials.

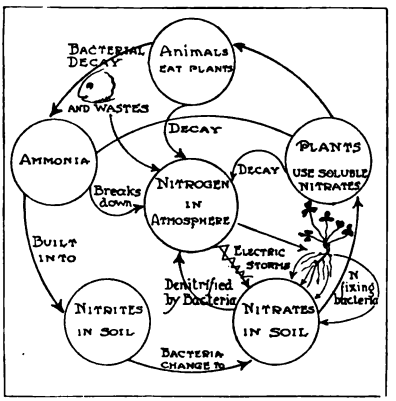


This shows how organic matter is broken down by bacteria so it may be used again by green plants.

Garden soil must be thought of as a place where millions of bacteria and other plants and animals live, some friendly and some unfriendly to the plants which are desired in the garden. If we were to examine soil for the presence of bacteria, we would find many more in rich soil than in sandy soil, and very many more near the surface than a little distance farther in the ground. Most

bacteria are found within six inches of the surface. An examination of sandy soil has shown something like 100,000 bacteria to the gram; in the soil of an ordinary garden, 1,500,000 to the gram, while in the soil surrounding privies and cesspools, as many as 115,000,000 to the gram may be found.

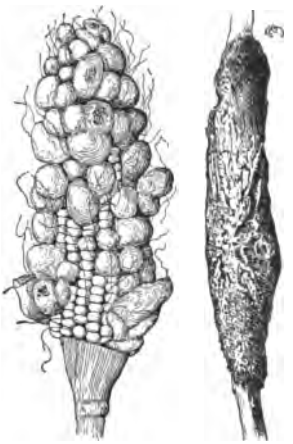
Bacteria in the soil break down organic material, such as dead bodies of plants and animals, and help to oxidize it. Some nitrifying bacteria act upon ammonia (a product formed in decaying) and change it to *nitrites*, while others change these nitrites to *nitrates*, which can be used by plants. Still other bacteria, as we have seen, are found living upon the roots of certain plants, such as clovers, peas, and beans. Sometimes a good farmer buys these bacteria and puts them into the soil, or *inoculates* his soil. These bacteria, although they live at the expense of the plants to which they attach themselves in little nodules, yet take the nitrogen out of the air which is held in the soil, and change it into a form that can be used by the plants. In the end the bacteria have reduced nitrogenous substances to a soluble form which can be absorbed through the roots. There are many other kinds of bacteria present in the soil, — some useful, and some harmful. The *denitrifying* bacteria which are commonly



The nitrogen cycle. Follow the arrows and find out what becomes of the nitrogen.

found in acid soils release the nitrogen in the soil to the air. Are these useful or harmful? Why? In some soils, a little one-celled animal is found which feeds upon useful bacteria, thus destroying the fertility of the soil. Many insects in the larval or pupal form (page 134) make their homes in the earth, and sometimes do much harm by eating the roots of plants. Earthworms, however, are useful animals in the garden, for they plow up the ground by boring their holes, thus passing much soil to the surface of the garden through their bodies. This loosens the compact soil and allows water to make its way through the ground. Sometimes we find moles and other boring animals which do harm.

Inoculating the soil with nitrogen fixing bacteria. (After Moore and Halligan).



Corn smut. Black knot. (After Mayne and Hatch.)

Other harmful plants.—While green plants make food for themselves, and for the world about them, other little plants do a great deal of harm. Some of these are called *fungi*. Among them are molds, rusts, smuts, scabs, and many other plant diseases. We find, for example, rust on asparagus, beans, and some other plants. Black rot is an-

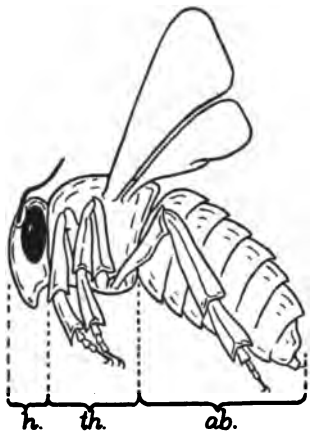
other plant enemy which grows upon beets and cabbages. Blights are formed on celery, cucumbers, and tomatoes, and other garden vegetables. Still another serious plant enemy is the scab of potato. All these fungi live at the expense of various green plants, and make them wilt, or the leaves curl up, or some other symptom of disease occurs This book does not tel. you exactly how to distinguish the various plant diseases. That should be a home project of your own, and there are many excellent pamphlets published by your state or the Department of Agriculture to which you can refer. For all of these fungous diseases, a very excellent cure is Bordeaux mixture, which is best applied in a spray.

Samples of Bordeaux mixture. Two and five show little settling and are the best.

Light in relation to fungous growth. — We must remember that fungi do not like light, and therefore the garden which is very well shaded and too moist makes a favorable place for them to grow. We should never have trees, or many bushes, planted around our garden, for not only do these larger plants take a great deal of "plant food" from the soil, but they may do considerable harm also by shading young growing plants.

Insect pests. — Everybody who has had a garden of his own knows that sooner or later he must expect to find insects doing damage there. The insect damage to all kinds of living trees and plants in the United States in a

single year is estimated at one billion dollars. Since we must expect insect pests the best way to prevent damage is to watch for them, and to get rid of them before they become numerous. If we remember that most insects lay their eggs on the plants which will later become their food, we can be on the watch for their eggs, and remove them before harm is done. Get the habit of looking for pests while weeding and cultivating your garden. The tomato "worm," for example, usually appears singly, and if picked off early a great deal of damage will be prevented.



An insect viewed from the side. Notice the head, thorax, and abdomen. What other characters do you find?

How to tell an insect. — We are all familiar with insects, yet how many boys and girls can tell exactly how to distinguish them from other animals? If we study the diagram of a bee shown here, we find that its body has three parts, the *head*, the middle portion or the *thorax*, and the hind portion called the *abdomen*. The insect has six jointed legs and may or may not have wings. By the above characteristics you can always distinguish an insect from other animals.

Experiment. — To study the life history of a moth and a butterfly.

a. Eggs

Method and Observations: In the field look on the under side of leaves for tiny ovoid structures (*eggs*) of moths and butterflies. The eggs of the cabbage butterfly may be found at almost any time on the under side of cabbage leaves.

Conclusion: Why are the eggs laid on the *under* side of *certain* leaves?

b. Larva or Caterpillar

Observations: Note that, besides true jointed legs, the caterpillar has others called *prolegs*. How many true legs are there and where are they located? How many prolegs are there? Locate the *spiracles* or breathing holes. Remember where they are located on an adult insect. Watch the caterpillar when it feeds. What kind of mouth parts does it have? Might it do damage to plants? How?

Conclusion: 1. Is a caterpillar a worm? (Look in a biology for the characteristics of worms.) 2. How might the larvæ of moths or butterflies be of economic importance?

c. Pupa

Materials: Cocoons of several species of moths with twigs or other parts attached should be furnished for this exercise.

Note: Moths spin a *cocoon* for themselves at this stage. Butterflies spin no cocoon but form a *chrysalis*.

Observations: Where do you find the cocoon or chrysalis? Of what does the cocoon seem to be composed? (The cocoon of the Cecropia is excellent for this purpose.) In a chrysalis locate by means of the body markings the head, antennæ or feelers, eyes, wings, legs, and spiracles. Are all the parts of an adult present?

Open a cocoon. What do you find inside? How do you explain this?

Conclusion: Making use of all the knowledge you have gained, write a brief description of the pupal stage of an insect and tell of what use this stage might be to the insect. Remember where you find these stages.

d. Adult or Imago

Method: Examine carefully an adult butterfly or moth.

Observations: How many body regions has it? How many legs? Wings? Antennæ? How does this stage differ from the pupal stage?

Note: All the changes undergone by an animal from the time it leaves the egg to the time it becomes an adult are known as the *metamorphosis* of that animal. If no great changes in form occur, the animal is said to have an *incomplete* or *direct* metamorphosis. But if changes in form such as in the butterfly or moth occur, the animal is said to pass through a *complete* or *indirect* metamorphosis.

Conclusion: 1. What insects that you have studied pass through a direct metamorphosis? An indirect metamorphosis? 2. If time permits, drawings might be made to illustrate the life history (metamorphosis) of a moth or a butterfly.

Life history of insects. — If we should watch the life of an animal from the egg to the time it develops into an adult and dies we would see its life history. There is a great similarity in the life history of those insects which pass through a complete metamorphosis. They have four stages. The egg is the first stage, often laid on a plant upon which the young insect will feed. This stage is followed by one known as the *larval* stage, during which the animal feeds and grows rapidly. Familiar examples of the larvae are the caterpillars or "worms" we see eating our garden vegetables, or the maggots we see in decaying meat. After the larva has eaten and grown larger, shedding its skin several times, it settles down, and if a moth, spins a cocoon, and becomes quiet for a period. This is known as the *pupal stage*. Finally the adult insect breaks out from the pupa, and lives a relatively short life, during which its eggs are laid, and the life his-

Monarch butterfly: adults, larva, and pupa on their food plant, the milkweed. (From a photograph loaned by the American Museum of Natural History.)

tory or cycle begins over again. Much harm is done in our gardens by insects in the larval stage, as, for example, caterpillars, cutworms, wireworms, and the like. A great many insects, in the adult stage, however, do damage by sucking juices from plants. These are bugs, and are known by their long sucking beaks. The seventeen-year locust or common cicada, and the squash bug, are good examples. Still other adult insects such as the locusts, commonly called grasshoppers, do much harm by chewing grass or vegetables which make up their food.

Collecting insects. — A very interesting and profitable pastime is the collection and identification of different kinds of insects. It is very easy to get an equipment necessary to collect them. A few cigar boxes, pieces of flat cork, insect pins, a cyanide bottle,[1] and a collecting net are all of the implements necessary. Insects are divided by scientists into *orders*, or groups, which have certain characteristics in common. There are nineteen orders, but only five or six are very common, and these are quite easily learned. Study any good elementary biology, and you will soon be able to distinguish the chief orders. For our purposes it is enough for us to know the insects which do harm in our gardens by chewing, and the insects which do harm by sucking.

Experiment. To learn to recognize insects that frequent flowering or garden plants.

Method: This work may best be taken on a field trip.

Note: Insects have been shown to be animals that have three

[1] A cyanide bottle is made by taking a wide-mouth bottle or a fruit jar, placing in it a small piece of cyanide of potassium, and covering this quickly with soft plaster of Paris. The cyanide is deadly poison. The fumes are sufficient to make you sick, so a cyanide bottle is best prepared by some older person, and should be handled with great care.

parts to the body, three pairs of jointed legs, feelers, compound eyes, and a more or less hard skeleton on the outside of the body. They may or may not have wings. They breathe through a system of air tubes called *tracheae*.

The following orders or groups of insects are likely to be found feeding or living upon flowering plants. The position and kind of wings and the kind of mouth parts are the guides by which we know the *orders* of insects.

Bees and Wasps (*Hymenoptera*, membrane wings). — The wings are gauzy and four in number. These insects have stings (look at the end of the abdomen).

Butterflies and Moths (*Lepidoptera*, scale wings). — Characterized by having two pairs of large wings, covered with tiny bright-colored scales. Head provided with a long *proboscis* or sucking tube which is coiled up when at rest.

Grasshoppers (*Orthoptera*, straight wings). — Found on most green weeds or garden plants. The mouth parts are fitted for biting. Hind wings, if present, are folded up lengthwise under the outer wings when at rest.

Flies (*Diptera*, two wings). — Usually small insects with but a single pair of gauzy wings. A short proboscis. Not plant feeders.

Bugs (*Hemiptera*, half wings). — A jointed proboscis which points backwards is the only sure mark of this group.

Beetles (*Coleoptera*, sheath wings). — Characterized by having a strong front pair of wings called *elytra*, usually covering the hind wings and always meeting in a straight line down the middle of the back. Mouth parts hard, pincher-like jaws.

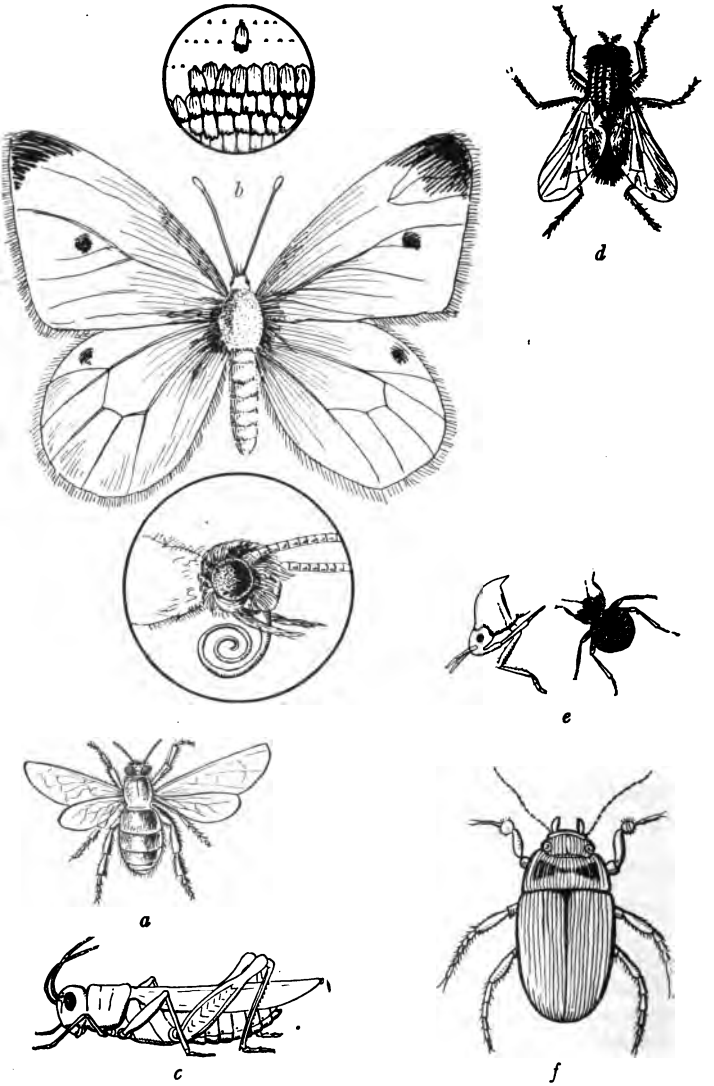
a. Field Work

Method: Collect as many different kinds of insects as you can, making careful notes as to the locality where the insect was found, the flowers which it frequents, the kind of food it was taking from the flower, and the order to which it belongs.

b. Laboratory Work

Observations: From boxes containing different kinds of insects pick out one from each order given above and give your reasons for placing that particular insect in the order which you have chosen for it.

Conclusion: 1. Why do certain insects always frequent certain flowers? Look at the insect, especially the mouth parts, very carefully and study the form of the flower before making your decision. 2. How would you pick out (*a*) bee, (*b*) butterfly, (*c*) a bug, (*d*) grasshopper from the above insects?



a, Bee; *b*, butterfly; *c*, grasshopper; *d*, fly; *e*, bug; *f*, beetle.

Some insect pests and how to fight them. — We must expect certain insect pests in our gardens, and because they prefer certain foods, only one or two kinds of insects will attack each plant. These paragraphs are not intended to give you more than a hint as to the insects and what to do to destroy them. You will be interested to make a home project of the disposal of the pests, and refer to the lists of bulletins and books given at the end of this chapter. You should always remember that where poisons are used, they are poisons to younger brothers and sisters, as well as to insects. Keep all spraying solutions, and also all other poisons, well out of the reach of children, and exercise care and common sense in using them. The following list of garden vegetables with their pests, and methods of fighting them, will be found useful.

Vegetable	Insect	Prevention and Cure
String beans	Aphids (plant lice)	Since these spread from weeds to beans, keep the weeds and other plants near the garden cut. Spray with kerosene emulsion or tobacco water.
	Bean weevil Bean beetle	Use same spray as above.
Cabbage	Plant lice	Soap emulsion or tobacco water.
	Cabbage worm	Use Paris green and pick off the worms.
	Cabbage borer	Use same methods.
Cauliflower	Cabbage worm	Use Paris green and pick off the worms.
Corn	Army worm (travels in large numbers)	Dust with Paris green, or if numerous, kill by means of kerosene.
	Corn root worm	Corn dies. Practice crop rotation.
	Drill worm	Crop rotation.
	Cutworm	Cutworms attack the silk and eat the end of cob. Spray with arsenate of lead.
	European corn borer	Report to state authorities; they will tell you what to do.
Cucumber	Cucumber beetle	Dust with ashes and use Paris green.
Potato	Potato beetle (bug)	Watch plants and pick off eggs or young beetles early. Spray with lime-Paris green.
	Slugs	Spray with Paris green or arsenate of lead.
Squashes	Squash borer	Burn vines, practice crop rotation. Kill young with kerosene.

Experiment. To illustrate the proper way of making some insecticides and fungicides; lime-sulphur, arsenate of lead, Bordeaux mixture, and kerosene emulsion.

Prepare several of these, using the quantities suggested in column "For Experiment" in table below. This table shows what to use and how to prepare the most commonly used garden sprays:

	Garden and Orchard Use	For Experiment	Directions for Making
LIME-SULPHUR FUNGICIDE For Delicate Foliage			Nearly cover the lime with water. When it is slaking add the sifted sulphur. Stir constantly and add a little water if it gets very dry. After five minutes add water to make specified quantity.
Quicklime . . .	2 lb.	2 gm.	
Sulphur	2 lb.	2 gm.	
Water	12 gal.	100 cc.	
LIME-SULPHUR SPRAY For Sucking Insects			Mix lime and sulphur and $\frac{1}{8}$ the quantity of hot water. Boil one to two hours, or until it has a dark amber color. Dilute to indicated quantity and apply warm.
Quicklime . . .	4 lb.	4 gm.	
Sulphur	3 lb.	3 gm.	
Water	10 gal.	85 cc.	
ARSENATE OF LEAD Spray for Chewing Insects			Mix the arsenate of lead thoroughly in the water.
Arsenate of lead paste (use $\frac{1}{2}$ the quantity if powdered is used) .	$\frac{1}{2}$ lb.	$\frac{1}{2}$ gm.	
Water	12 gal.	100 cc.	
BORDEAUX MIXTURE Fungicide and Germicide			Dissolve the sulphate in a large wooden vessel, or in a glass if a small quantity. Slake the lime to make a creamy mixture, then add water to make thin. Strain the milk of lime through cheesecloth into the solution of copper sulphate.
Copper sulphate .	1 lb.	1 gm.	
Quicklime . . .	1 lb.	1 gm.	
Water	12 gal.	100 cc.	
LIME-PARIS GREEN Spray to Control Potato Beetle			Mix the Paris green and water and add filtered milk of lime.
Paris Green . . .	2 oz.	$\frac{1}{3}$ gm.	
Lime	$\frac{1}{2}$ lb.	$\frac{1}{2}$ gm.	
Water	12 gal.	100 cc.	
KEROSENE EMULSION Spray for Plant Lice			Dissolve the soap in about $\frac{1}{10}$ of the water, which must be boiling hot. Warm the kerosene and add. Stir vigorously until creamy. Add the remainder of the water.
Hard soap . . .	$\frac{1}{4}$ lb.	$\frac{1}{4}$ gm.	
Kerosene	1 gal.	10 cc.	
Water (soft) . . .	12 gal.	100 cc.	

Insects harmful to fruit trees.—The codling moth ruins $3,000,000 worth of fruit each year in New York state alone. Most of us know this pest as the "worm" in the apple. Spraying the trees when the petals begin to fall is the best method of destroying this pest. In some localities there is more than one brood of codling moths in summer, in which case the spraying has to be repeated for the other broods. The canker worms, tent caterpillars, plum curculio, and scale insects also attack fruit trees. Borers sometimes do much injury to fruit trees, and are very hard to fight as they work into the tree trunk near the ground. Digging them out and filling holes with carbon bisulphide are the best ways to fight them.

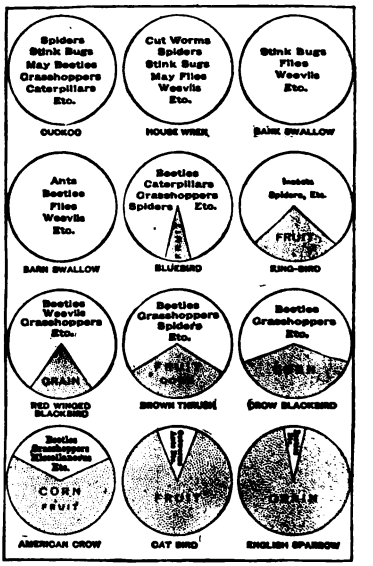
Other plant enemies. — Those of us who have lived on the farm know some other garden pests. The ordinary cottontail or the common gray rabbits often do much damage by eating garden vegetables and fruits, and especially by gnawing young fruit trees. They live in burrows which they dig under cover of weeds and thick grass. They breed rapidly, sometimes having several litters of from two to four each, in a single season. Rats from the barn, and more frequently field mice, do a great deal of damage to our gardens and trees. The ground mole, although in some ways useful because of its diet of insect larvae and grubs, digs up our lawns and gardens so as to become a pest about the place.

Insect friends. — Everybody knows that bees are useful for they not only make honey but they also do a far greater good by carrying pollen from flower to flower, thus aiding in the growth of seed and fruits. We shall discuss the life habits of bees more fully in our next book. The ichneumon flies, near relatives of the bees, are of much

value to man because they lay eggs on the bodies of caterpillars harmful to vegetation. As these eggs develop the young ichneumons live on the body of the caterpillar and eventually kill it. Some beetles are of use as garden friends, especially the "lady bug" or lady bird beetle, which feeds upon plant lice or aphids. Some insects feed upon weeds and they too can be classed as our friends.

Two valuable garden friends.

Other garden friends. — Insects and some animals, such as field mice, are kept under control by birds. Our neighbor the robin, whom we sometimes begrudge a few cherries, is of more use than harm because of his insect diet. Our earliest visitor, the bluebird, lives largely on injurious insects, as do the woodpeckers, cuckoos, kingbirds, and many others. Many birds live upon insects which are most numerous around them. When great numbers of insects are present, birds do an immense amount of good.



Food of some common birds. Which of the above birds should be protected by man and why?

Birds eat weed seeds. — Birds also help us in our gardens by eating weed seeds; especially beneficial are our native sparrows (not the English sparrow), the bobwhite, the mourning dove, and others. Those birds which stay with us late in the fall often devour great numbers of weed seeds, which are thus prevented from sprouting and growing the following year. Sometimes birds, such as owls, eat rats, field mice, and other pests. We should all band together to prevent the destruction of our native birds, and to encourage nesting in the trees and shrubs around us. House cats, and more often stray cats, are of great harm, because they either kill or frighten away the birds and prevent them from nesting in the neighborhood.

The common toad, an insect eater.

Other friends of the garden. — We do not think of a toad as being a beautiful animal, but every boy and girl who keeps a garden should have a friendly toad living under one of the big-leaved plants in it. Toads have been found to eat no less than eighty-three different kinds of insects, most of which are injurious. A single toad has been estimated by Kirkland, on account of the cutworms which it might kill, to be worth nearly twenty dollars a season, if the damage done by each cutworm were estimated at

only one cent. Snakes, most of which are harmless, are also garden friends. The black snake and milk snake feed largely on rats and mice, while the common green snake eats injurious insects, and the little brown De Kay and garter snakes have a diet including slugs, which sometimes do much damage in the garden.

REFERENCE BOOKS

Forbush, *Useful Birds and Their Protection*. Massachusetts Board of Agriculture.

Hodge, *Civic Biology*, Chapters IV, XII, XIV. Ginn and Company.

Hodge, *Nature Study and Life*, Chapter XVI. Ginn and Company.

Hunter, *A Civic Biology*, Chapter XV. American Book Company.

Hunter, *Laboratory Problems in Civic Biology*, Chapter II. American Book Company.

Kellogg and Doane, *Economic Zoölogy and Entomology*, Part II, Chapters XXX, XXXII, XXXIII, XXXIV, XXXV, XXXVI. Henry Holt and Company.

Mayne and Hatch, *High School Agriculture*, Chapters V, VI. American Book Company.

Merriman, *Birds of Village and Field*. Houghton Mifflin Company.

Moore and Halligan, *Plant Productions*, Part II, Chapter VII. American Book Company.

Sanford, *The Story of Agriculture in the United States*. D. C. Heath and Company.

Spillman, *Farm Science*, Chapters XII, XIII, XIV. World Book Company.

Trafton, *Science of Home and Community*. The Macmillan Company.

Webster, *Value of Insect Parasitism to the American Farmer*. U. S. Dept. of Agriculture Yearbook, 1907.

Weed, *Farm Friends and Farm Foes*. D. C. Heath and Company.

U. S. Dept. Agriculture, *Farmers' Bulletins*. (There are very many of these, each treating a definite insect pest, or dealing with a definite fungus.) Ask to be placed on the mailing list for the monthly list of bulletins. Then you may select and send for those which interest you.

PART VI. DEVICES FOR LABOR SAVING AND CONVENIENCE

CHAPTER XXI

SOME SIMPLE MACHINES IN THE HOME

Problems. — 1. *To understand the principles underlying simple machines used in and about the house.*

2. *To understand what advantages machines offer.*

Experiments and demonstrations. — 1. To demonstrate the principle of levers.

2. To illustrate changing speed by use of wheels of different diameters, joined by belt or gears.

Project 1. — TO KEEP THE MACHINES OF THE HOME IN GOOD WORKING CONDITION.

1. Learn how to operate all the different household machines.

Learn what oiling is necessary, and how to keep free from dust and dirt.

2. What other attention is needed from time to time?

3. Study the mechanism of the more complicated machines to know how the machines work.

4. If needed repairs are too difficult for you to do, be ready to advise where repairs should be made.

Suggested Projects.

1. TO DETERMINE THE TYPES OF MACHINES AND THE MECHANICAL ADVANTAGE OF TEN DIFFERENT MACHINES FOUND IN MY HOME.

2. TO STUDY THE DIFFERENT TYPES OF WASHING MACHINES AND DECIDE WHICH IS BEST SUITED TO HOME USES.

3. PROCURE HOUSEHOLD SCALES. HAVE THEM ADJUSTED BY DEPARTMENT OF WEIGHTS AND MEASURES. WEIGH GROCERIES, MEATS, ETC., BOUGHT, AND SEE IF CORRECT WEIGHTS ARE DELIVERED.

4. TO DETERMINE HOW A LAWN MOWER WORKS, WHAT TYPES OF SIMPLE MACHINES ARE IN IT, AND APPROXIMATELY THE RELATION OF POWER TO WORK.

5. TO DETERMINE WHAT MACHINE PRINCIPLES ARE USED AND HOW THEY ARE APPLIED IN THE DOOR KNOB, LATCH, AND LOCK.

Thought Questions.

1. May the hands of a clock be considered as machines of the lever type?

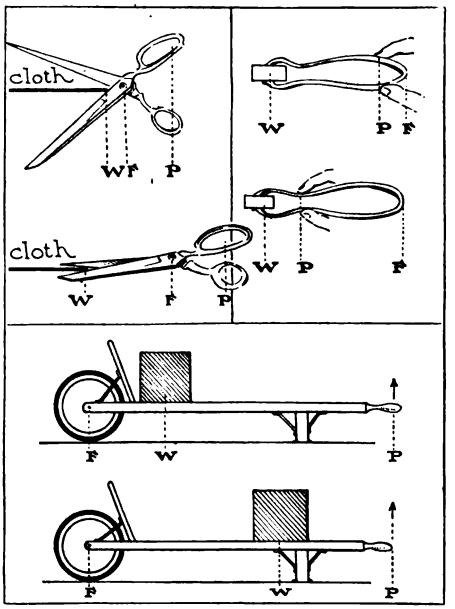
What class of lever are they, and what advantages as machines have they?

2. Explain the type of simple machine you use when you wind a watch or a clock.

Why we use machines in our homes. — If we had lived a great many years ago, we would have found that there were very few devices which enabled our ancestors to save labor in their homes. Much work was done by hand, and a few simple machines, such as churns, spinning wheels, wagons, and the like, were used to do most of the mechanical work. In the present era, an age of machinery, we have come to save time and also save our own energy by using machines to help us do the work. We find also that machines are usually much more efficient than we are, and so it is that we have year by year an increasing number of devices for labor saving in our homes. Each year some new device is perfected, and it is a wise housekeeper who can select from such a multitude of machines now offered in the market those which are mechanically perfect, and serviceable and durable. It is the pur-

pose of this chapter to point out a few of these machines, and to try to explain the simple principles which underlie their construction and regulation.

Two types of machines used in the home. — The lever and the wheel and axle are two types of simple machines which play an important part in the construction of many household devices.



In which of each of these three cases will the same resistance be overcome by a smaller force? *P*=force. *W*=weight (resistance). *F*=fulcrum.

If we look at a pair of shears, for example, we find them to be made of two pieces of metal, held together at one point by a rivet with the inner edges sharpened at an angle. If we try to cut a piece of thick cloth with these shears, we find it much more difficult to cut the cloth when it is placed farther away from the point where the parts of the shears are rotating, while it cuts much easier close to the point of rotation. The shears illustrate the *lever*, the force we exert being called the *force*, the resistance we overcome in the cutting of the cloth the *weight*, since it is measured in units of weight, and the point at which the shears revolve, or turn, is called

the *fulcrum*. Another example of such an instrument is seen in the sugar tongs, where we find it is much easier to hold the lump by placing the fingers close to the lump than it is if we were to apply the force far away from it.

The wheelbarrow is a lever. Almost any boy or girl who lives in the country knows that it is easier to carry a heavy load on the wheelbarrow if the load is placed nearer to the wheel than to the handles (see diagram). The nearer the load can be placed to the wheel, the greater the ease with which the load can be lifted and carried. All of these machines mentioned use a common principle, that of the lever. Let us now study and experiment more closely, and see if we can understand the principles underlying it.

Experiment. To demonstrate the principle of the lever.

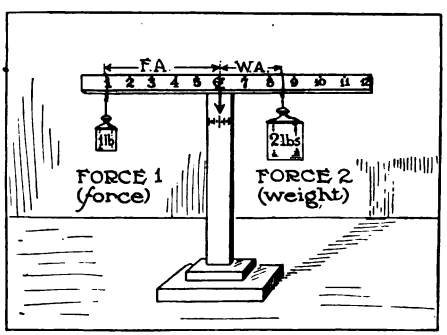
Materials: Ruler with hole in the center. Weights and string.

Method: With the lever illustrated find out where a force of 1 pound must be applied on the *force arm* to balance the different weights suggested in (*a*), (*b*), and (*c*), applied on the *weight arm*.

(*a*) Place 2 pounds 2 inches from the fulcrum.

(*b*) Place 2 pounds 4 inches from the fulcrum.

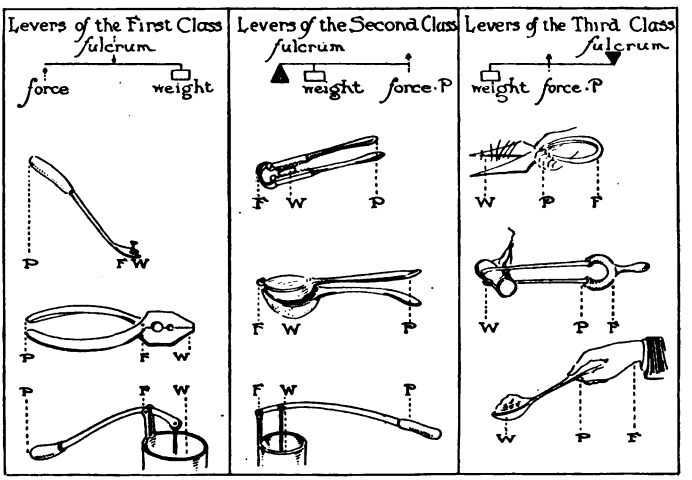
(*c*) Place 6 pounds 1 inch from the fulcrum.



From the result of the experiment tell what is wrong in the picture.

Observation and conclusion: Where will a force of 1 pound need to be applied to balance the weight in each of the cases (*a*), (*b*), and (*c*)? Can you work out the principle of levers by comparing the forces and lengths of arms in each case? What statement will you suggest for the law of levers?

Three classes of levers. — There are three classes of levers which depend on the position of the fulcrum, the weight, and the force. The relative positions of these are as follows: In levers of the first class, the *fulcrum* comes between the weight and the force; in levers of the second class, the *weight* comes between the fulcrum and the force; in levers of the third class, the *force* comes



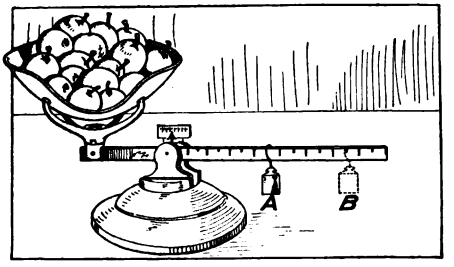
Common examples of the three classes of levers.

between the weight and the fulcrum. The shears belong to the first class of levers, the wheelbarrow to the second class, and the sugar tongs to the third class.

Mechanical advantage. — We use ordinarily a machine to overcome a force greater than that which we apply. If by means of a machine we can lift 200 pounds by applying a force of 25 pounds, then the mechanical advantage of the machine is 8; it is equivalent to the force moved divided by the force applied. With levers of the third class

we must apply more force than the resistance to be overcome. Then why use such a machine? There is another advantage for which some machines are used, that is, speed and distance moved. The advantage of levers of the third class is that of speed or distance covered. Notice how this is shown in the sugar tongs.

How we weigh things. — A pair of scales at home is a necessary thing, for it may save more than its cost many times over in checking up the weight of groceries and other materials. Most scales in use are dependent on the principle of the lever. In the scales in the picture, can you tell whether you would get more or fewer apples if the sliding weight were placed at point A or at point B? Can you explain why? Another household scale not dependent on the principle of the lever is the spring balance. To explain such a scale, let us suspend a coiled wire with a pointer fastened at the bottom. Let us now fasten to the wire, weights weighing 10, 20, and 30 grams respectively. As the weights pull the wire down, mark the position of the pointer on the scale representing 10, 20, and 30 grams. We might continue this scale to make several more marks, and as long as the elasticity remained in the wire, we could then use this for weighing purposes. This is the principle of the spring balance or postal balance used for weighing letters.



Principle of the lever used in weighing.

The lawn mower. — If you have pushed a lawn mower

along a level lawn, you must have noticed that the force you applied is distributed in two directions. You push the lawn mower forward, but you also push it downward. This downward motion is applied in increasing the pressure of the wheels against the ground, thus causing them to turn around without sliding. The horizontal force is used in moving the wheel forward, and also in turning the wheel. If you turn a lawn mower upside down so that the revolving knives do not hit the grass, you will notice that it runs more easily. A large part of your energy, then, goes in moving these knives, which are retarded by pressure against the grass and the lower part of the lawn mower. If two boys work together in cutting a lawn, the work can be made much lighter by one boy fastening a long rope in front of the mower and pulling. Can you explain why?

The push (*B*) is divided into two parts: force *A* downward, which gives the necessary friction for the wheels to turn, and force *C*, which rotates the blades and moves the mower forward.

Wheels and runners. — Why do our wagons have wheels and our sleds runners? Perhaps you know that when we move one body over another, a certain amount of resistance known as *friction* must be overcome. Have you ever pulled with all your might to drag a heavily loaded box over the floor and then placed one or more rollers, such as can be made from a broom handle, under the box and found how easily it could be pulled? In much the same way a load on a wagon is moved over the bare road more easily than the same load on a sled. The sled runner slides over the road surface, while the wagon wheel rolls over it; and *sliding friction* is greater than *rolling friction*.

But why not use wheels on ice and snow? If you ever tried your roller skates on ice you know the difficulty of getting started. This is because of the lack of sufficient friction. Such smooth surfaces as glass, ice, and well-worn snow have very little resistance to the movement of hard objects over their surfaces. Sled runners have many more points of contact with a supporting surface than have wheels; but because of the very low friction between ice and smooth steel, steel runners are better for snow and ice than wheels. With skates there are fewer points of contact and the friction is sometimes reduced still more for another reason. When skating in moderate weather, the pressure, due to your weight, melts the ice under the runners and you really glide over water. This water freezes instantly after the skates have left it.

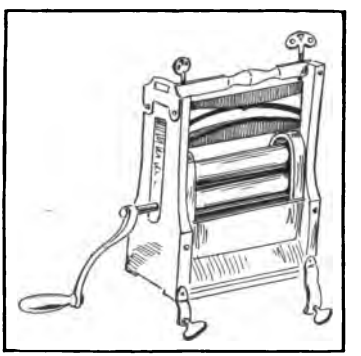
Ball bearings.

The law of machines. — Machines do not *make* energy. They simply *transfer* or exchange force or mechanical energy from one place to another. We shall see as we go on in our study of science that *energy* is simply the *ability to do work*. Sometimes this energy is locked up, as in coal, which gives heat when burned, or it may be evident as in the power in the running stream, or in the waves, or in the wind. By use of a machine we may transfer this energy or power from one place to another, and by means of a machine get work done more effectively. The chief value of machines lies in their enabling us to overcome a large resistant force by applying a small force. But we must

remember that we can get no more work out of a machine than we put into it. The law of machines may be stated as follows: *The force applied to a machine times the distance through which it acts equals the resistance overcome times the distance through which it is overcome.* That is, if you move a 200-pound weight 1 foot by applying a force of 20 pounds, this force would have to act through a space of 10 feet. $200 \times 1 = 20 \times 10$.

Unit of work. — The term we use for the unit of work is the *foot pound.* This is exactly what its name indicates. If we lift a pound one foot, the result is a foot pound, or if we lift four pounds four feet from the ground, we do sixteen foot pounds of work. In other words, the work equals the weight multiplied by the distance.

The application to some other machines. — If we now apply this rule to such other machines as the meat chopper, clothes wringer, coffee grinder, and ice cream freezer, we find that we can easily estimate the amount of force which must be exerted to make them do their work. In the machines just mentioned, we apply force by the hand with a crank or handle which is revolved through a circular path. All of the machines belonging to this type are known as the crank and axle, or the wheel and axle type. The work is done at a point on the circumference of the axle. If the circumference of the roller of the clothes wringer is



The clothes wringer; a crank and axle machine.

six inches, and the circumference of the circle described by the hand in operating the handle is sixty inches, then the resistance of 200 pounds at the roller would require you to expend only twenty pounds at the wringer handle. Express this in terms of the law of machines.

Wheels of different diameters connected by belts or interlocked by gear teeth are used for the purpose of changing speed as well as for the reason of mechanical advantage. A study of a few home machines will make this apparent and explain the purpose of their use.

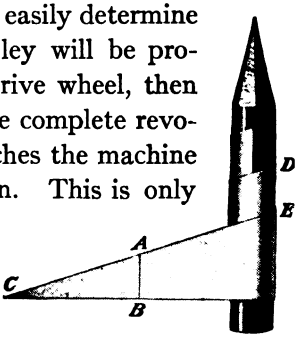
Experiment. — To illustrate changing speed by use of wheels of different diameters joined by belt or gears.

Materials: A Dover egg beater, or drill with gear and wheels. Bicycle.

Method: (*A*) Mark one point on the working part of the egg beater. Observe how many times this revolves for one complete turn of the handle. Try this three times. (*B*) Count the number of cogs on the two wheels which connect the force end of the machine to the work end. What is the relation of the numbers of cogs? (*C*) Make similar comparison of the cogs on the rear axle and on the sprocket wheel of your bicycle. Find the number of revolutions of the rear wheel to one revolution of the crank. What general rule regarding change of speed is suggested to you by these observations?

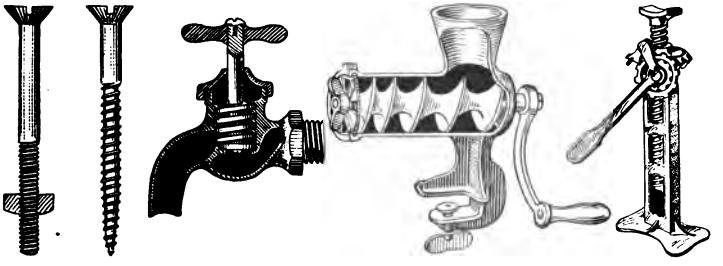
The sewing machine. — A great many other types of machines can be found in our homes, but one almost always present is the sewing machine. Since 1850 these machines have been improved more and more, so that now their work is extremely rapid and efficient. A study of the part that does the stitching is somewhat too complex for us at the present time, but would make a very interesting home project which could be studied by means of diagrams furnished by almost any good machine supply house. One good project which could be worked out in the laboratory would be to find out how power is trans-

mitted in the sewing machine. Notice we have a treadle which transfers power to the drive wheel. If we measure the diameter of this wheel, and the diameter of the pulley over which the belt passes, we can easily determine how many revolutions of the pulley will be produced by one revolution of the drive wheel, then by carefully turning the pulley one complete revolution, we can find how many stitches the machine takes in each complete revolution. This is only one of the problems which can be worked out in connection with a sewing machine.



Observe how the screw is in reality a spirally inclined plane. Explain diagram.

Other machines. — A number of other mechanical principles are found in many machines used in the home. Among them are the inclined plane, the wedge, the screw, and the pulley. We have all used the inclined plane in rolling heavy objects like the barrel up a grade. And we have used the wedge, which is really two inclined planes



Illustrating the use of the screw.

put side by side, points together, in the ax or hatchet. The common wedge when driven into the wood, forces it apart. The screw is nothing more or less than a long inclined

plane placed in the form of a spiral. We have seen the use of the jack screw under automobiles in case of tire trouble. Again it is simply the use of force or energy exerted on an inclined plane which runs round and round the jack. Pulleys are not used so often in the home although a familiar example is seen in the supports of the painter's staging. A glance at the diagram will show how they are used.

With this pulley a weight of 600 pounds can be supported by a force of 100 pounds.

The small vacuum washer. — Many homes nowadays have washing machines. A small hand washer using the vacuum principle does good work. The cone-shaped metal washer is fastened to a handle and the large end is open. There are holes in the sides of this cone. If this washer is pushed down and lifted up alternately with a great deal of vigor, air will be forced out on the down stroke, and the vacuum produced on the up stroke sucks the water up through the clothes under the washer. The use of such an instrument as this is very effective in washing blankets and delicate materials which may be injured by rubbing. What is the explanation of suction?

Washing machines. — Washing machines are of two kinds as far as the inside working is considered. In one the system of vacuum domes is similar to the one just described and is operated mechanically inside of the closed tub. In the second type the clothes are held in a perforated drum which revolves first in one direction and then in the other. This drum sets in water held in the outside container. The constant whirling of the water back and forth

and through the clothes washes them. This machine may be operated in a number of different ways, by hand lever, crank, water motor, or electric motor. The hand-operated machines are very efficient, but require time and attention. The motor-driven ones are much more expensive, but save work.

REFERENCE BOOKS

Bachman, *Great Inventions and Their Inventors* (Sewing machine). American Book Company.

Barber, *General Science*, Chapter X. Henry Holt and Company.

Black and Davis, *Practical Physics*, Chapter II. The Macmillan Company.

Brownell, *General Science*, Chapter VII. P. Blakiston's Son and Company.

Caldwell and Eikenberry, *General Science*, Part III, Chapters XV, XVI. Ginn and Company.

Central Scientific Company, Chicago, *Catalogue* with illustrations of simple machines for projects.

Child, *The Efficient Kitchen* (For teachers), Chapters II, XIV. McBride, Nast and Company.

Clark, *An Introduction to Science*, Chapter XXXII. American Book Company.

Clark, *The Care of a House* (For teachers). The Macmillan Company.

Carhart and Chute, *Physics with Applications*, Chapter VI. Allyn and Bacon.

Fall, *Science for Beginners*, Chapter XXXIII. World Book Company.

Hessler, *The First Year of Science*, Chapter X. Benj. H. Sanborn Company.

Hoadley, *Essentials of Physics*, Chapter III. American Book Company.

Hodgdon, *Elementary General Science*, Chapter XIV. Hinds, Hayden and Eldredge.

Knott Apparatus Company, Boston. *Catalogues* with illustrations of simple machines for projects.

Lynde, *Physics of the Household*, Chapters I, II, III. The Macmillan Company.

Singer Sewing Machine Company, *Mechanics of Sewing Machines*.

Van Buskirk and Smith, *The Science of Everyday Life*, Project XV. Houghton Mifflin Company.

Van Rensselaer, *Manual of Home Making* (Teachers' use), Chapter III. The Macmillan Company.

Williams, *How It Works*. Nelson Company.

CHAPTER XXII

HOW ELECTRICITY IS USED IN THE HOME

Problems. — 1. *To learn the properties of magnets and how magnetism is produced by electricity.*

2. *To find out what electromagnets are and what they will do.*

3. *To understand the working of electric bells and how to install them.*

4. *To find out how a simple motor works.*

5. *To see how electricity gives heat.*

Experiments. — 1. To determine laws of magnetic poles.

2. To magnetize an iron bar in the field of another magnet and in the earth's magnetic field.

3. To make an electromagnet.

4. To demonstrate the electric bell.

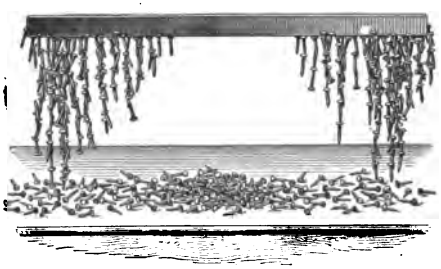
Project I. — TO INSTALL AN ELECTRIC BELL IN MY HOME.

1. Plan wiring, bell button, and battery location.
   Concealed or outside wiring. Diagram.
2. Materials needed.
3. Make the installation.

Suggested Projects.

1. TO MAKE A COMPASS OR A DIPPING NEEDLE.
2. TO MAKE A PERMANENT PRINT OF A MAGNETIC FIELD.
3. TO MAKE A TOY ELECTRIC MOTOR.

Electricity in the home.—Your father and mother can doubtless remember the first time they saw the trolley car or the incandescent light; it was only a few years ago that the wireless was first used. So we see that the harnessing of this great power, electricity, has been comparatively recent, and that we are just at the beginning of an era of electricity and electrical devices. Modern households, if well equipped, may have many of these labor saving and useful instruments. There are three general types of electric devices. Examples of them are the electric doorbell, the motor which drives the machine, and the electric iron. The bell and the motor depend upon electromagnetic action to do their work, while the iron depends upon the heating effect of the electric current. In order to understand even a little about these devices, it is necessary for us to know something of the properties of electricity, particularly in its relation to magnetism. Every boy and girl has played with a magnet or some toy in which a magnet was used and yet may not know just what a magnet is.



The magnetic strength is greatest near the ends.

Magnets and their properties.—A great many years ago, iron ore was found in Magnesia, Asia Minor, which had the property of attracting to it other pieces of iron. This ore was called magnetite, and the name magnet was thus derived from the name of the country in which it was first found. We can make artificial magnets, either by rubbing a piece of steel with a natural magnet, or by hold-

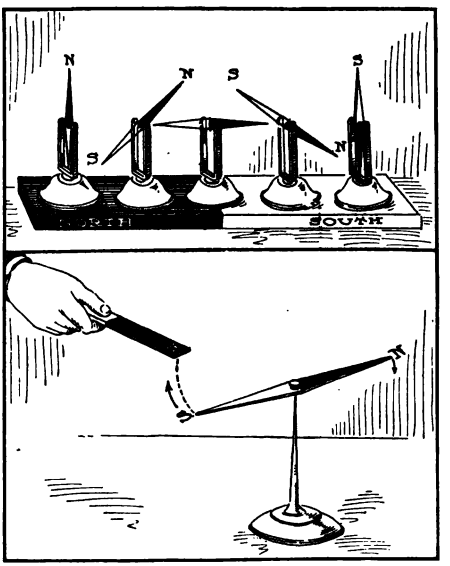
ing it near one. In early times artificial magnets were always made in this way, but since we have come to generate electricity and send it in a current through wires, we find that we can make better magnets by its use. Of this process we shall learn later.

Experiment. — To determine laws of magnetic poles.

Materials: A bar magnet. A suspended magnet (may use needle of compass).

Method and Results: Bring the north pole of the bar magnet near the south pole of the compass needle. Result? Bring the south pole near the north pole. Result? Make similar tests with the south pole of the bar magnet. Results?

Conclusion: Formulate a law concerning the attraction and the repulsion of magnetic poles.

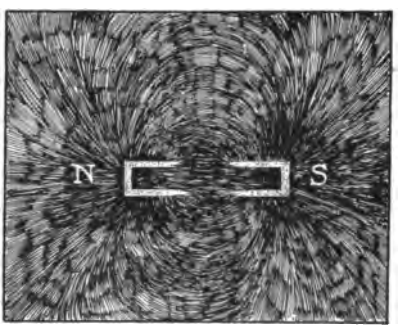


What law of magnetism is illustrated here?

The properties of magnets. — As we have seen magnets attract unmagnetized iron and steel. They will also attract two other metals, nickel and cobalt. The attractive force is greatest near the ends of the magnets. These points of greatest attractions are called the *poles* of the magnet. Halfway between the poles is the magnetic equator, a region of practically no magnetic attraction. If a magnet is suspended so that it swings freely in a horizontal plane, it

takes a north and south direction, the pole pointing north being called the *north pole*, and the pole pointing south, the *south pole*. If we bring the north pole of one magnet near the north end of a suspended magnet, the north pole moves away. If we bring the south pole of a fixed magnet to the north pole of a movable one, the south pole is drawn toward the north. These curious facts are always noticed when two magnets are brought together, and from this we are able to state the law, which is as follows: *Like magnetic poles always repel, and unlike magnetic poles always attract, each other.*

The magnetic field. — It is not necessary to touch a small piece of iron such as a tack in order to attract it. You have often noticed tacks or bits of iron jump across the air space to a strong magnet. A compass needle will turn when several feet away from a strong magnet. These facts indicate that the influence of the magnet extends in all directions. This force decreases as the distance increases. The space about a magnet in which magnetic influence exists is called the *magnetic field*. It is because the earth itself is a huge magnet and has surrounding it a magnetic field, that the compass needle takes a definite direction. Every magnetic field is filled with *magnetic lines of force* which are imaginary lines denoting the direction of the magnetic force.



A magnetic field. Iron filings scattered over a magnet arrange themselves in the lines shown.

Experiment. — To magnetize an iron bar in the field of another magnet and in the earth's magnetic field.

Materials: A three-inch length of soft iron. A strong bar magnet. A three-foot length of iron gas pipe or soft iron rod. Compass. Dipping needle. Fine iron filings. Hammer.

Method: (*A*) Test the three-inch iron rod by dipping it in iron filings. If it shows no magnetic effect, place one end of it very near to one pole of the bar magnet. Tap it two or three times with the hammer. Now test it in the iron filings to see if it has become a magnet. (*B*) Test the iron gas pipe by holding first one end and then the other near the north end of the compass needle. If both ends attract the north pole of the needle it is *not* magnetized and is ready to use. If one end attracts while the other repels, its magnetism must be removed. This may be done by holding the pipe horizontally in an east and west direction and striking it with the hammer. After a few trials you will find that its magnetism has disappeared. The compass indicates the north and south direction. Place the dipping needle so it is free to swing in this plane. Hold the gas pipe in a position parallel to the dipping needle and strike one or two blows on the end with the hammer. Test to see if the pipe now is a magnet by holding first one end and then the other near the compass needle.

Results and Conclusion: What are the results in (*A*) and (*B*)? What is one way of magnetizing substances? Why does the dipping needle take the direction that it does? Why point the gas pipe in that same direction? Why do tools standing in one place in the house sometimes become magnets?

Magnetic property of an electric current. — If a wire connecting the two poles of a dry cell is brought down over a compass in a north and south line, the needle will move just as it would if we brought another magnet near it. This is evidence that a magnetic field surrounds the wire. If the wire is coiled by winding a close layer on a lead pencil and a current sent through it the wire will act like a magnet with two poles. This is shown by bringing first one end of the coil and then the other end near the north end of the compass needle, for one end will attract and the other end will repel. The coil of wire behaves

like a magnet. If a bar of soft iron be slipped inside the coil, it will act as before, but with far greater strength. Such a device as this last, that is, a bar of soft iron having a current of electricity passing through a wire surrounding it, is known as an *electromagnet*. The magnetic property of an electromagnet ceases the instant the electric current is shut off, and appears again when the current is turned on. The electromagnet is the basis of many household devices, some of which we are now going to study.

Experiment. — To make an electromagnet.

Materials: Dry cell. Push button. Insulated No. 20 copper wires. Soft iron rod three inches long. Compass. Small iron tacks.

Method and Result: (*A*) Connect one pole of the cell to one screw of the push button. Connect the other wire to the other pole of cell and other screw of push button. Bring a portion of the wire down over and parallel to the compass needle. Press the button to cause an electric current to flow through the wire. Result? The current flows through the wire toward the zinc pole of the cell. Make diagram to show direction of the current through the wire, and which way the north end of compass needle is deflected. (*B*) Wind the insulated copper wire in close layers around the soft iron rod, remove the rod, connect the ends of the coil into the electric circuit. Hold one end of the coil near the north pole of the compass needle. Press the button to pass an electric current. Result? Hold the other end of the coil near the north end of the compass. Result? Make a careful diagram showing the windings of the coil and connections to the cell. Let arrows indicate the direction of the current in the wire. Label the north and south poles of the coil. Put the iron rod inside the coil and test again. Result?

Conclusion: How can you make an electromagnet? What rule can you make to show the relation between the direction of the current of electricity around the coil and the polarity of the coil?

An electric bell system. — The essential parts of the electric bell system are the bell, connecting wire, the button, and a source of electric current, which usually is the

dry cell. The button is a device for making and breaking the circuit. When you press the button you connect the parts of the wire which at other times are separated by an air space. Electricity can flow only when there is a complete metal circuit from one pole of the battery back to the other pole. The wire used must be insulated to prevent leakage and short circuits, should the wire happen to come in contact with metal or wet wood, or two parts of the wire come together.

Experiment. — To demonstrate the electric bell.

Materials: Electric bell. Electric cell. Wires. Push button.

Method: (*A*) Study the bell. Make out these parts: two binding posts, electromagnet, armature, spring, contact post, contact screw, hammer, gong. Trace the wire connection through the different parts from one binding post to the other.

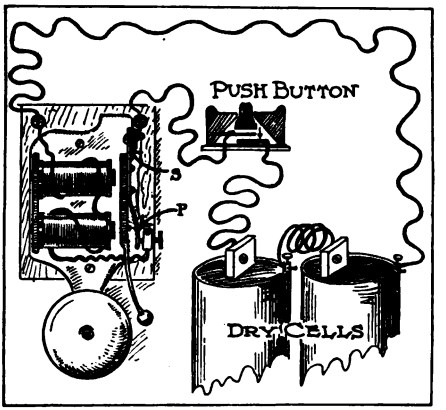
Note: In some bells a part of the wire circuit is omitted, and the base of the bell carries the current from one part of the bell to one of the binding posts. Is that the case with the bell in hand?

Connect bell, cell, and button in circuit. Adjust contact screw if necessary. Make the bell ring.

Explanation: Explain in detail just why the bell rings. Make diagram and trace, using arrows, the passage of the current from the cell back to the cell.

How the bell works. — The bell itself consists of the base support, binding posts, electromagnet, armature, hammer, spring, contact post, and gong. These parts are all shown in the diagram. The wires from the battery and button are connected to the two binding posts; the current then goes to the electromagnet, to the spring and armature, to the contact post, and thence back to the other binding post. A strip of platinum on the armature makes contact with a platinum point from the contact post. These two pieces of platinum are held in position touching each other by the spring when no current flows.

Now suppose the circuit is closed by some one pressing the push button. A current flows through the entire circuit. The electromagnet attracts the soft iron armature and pulls it away from the contact point at *P*, making a gap or break in the circuit. The current instantly stops, the magnetism disappears, the spring (*S*) brings the armature back and closes the circuit, a current flows again, and everything is repeated. This backward and forward movement of the armature causes a similar vibration of the hammer which strikes the gong on every pull of the magnet. This vibration and resulting ringing of the bell continues as long as the button is pressed.



The electric bell system.

Sources of current. — The dry cell has about the same strength as the wet cell, which is still used to some extent. For the usual house circuit two cells will be ample and they should be joined, carbon (inside pole) of one to zinc (outside pole) of the other. Either one of these types of cells needs renewal or replacement from time to time. Where electricity is used for lighting it is possible by installing a special device for reducing its pressure, to use it for the doorbell system. The device used is called a *transformer*. A transformer made for bell ringing circuits

can be bought for one or two dollars. The cost of operation is about the same as for renewals of batteries in the older systems, but there is no trouble about having to renew batteries, which as a rule means an interval of time when the bells will not ring.

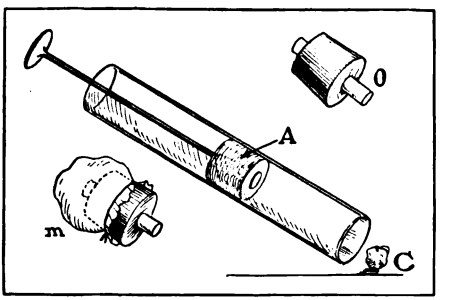
The telephone. — The telephone can almost be called the errand boy of the household. It is one of the biggest of labor savers. There are a number of complicated electrical devices involved in the complete equipment. The receiver itself has an electromagnet in it and the vibration of an iron disk, somewhat similar to the vibration of the armature of the electric bell, causes sound waves which we hear. A more complete explanation of the telephone will be given when we study communication at a future time.

Electric control of sewing machine. Find the motor which drives the machine

Commercial motors in the home. — The importance of the electric motor in the home can well be appreciated when one stops to think of the hard hand labor which is replaced by motor-driven

washing machines, ice cream freezers, grinding wheels, sewing machines, vacuum cleaners, and ironing machines. They are inexpensive for the amount of work they do, and save the strength of the housekeeper for other important duties.

The vacuum cleaner and sweeper. — The electric vacuum cleaners are of two types. One produces a vacuum by means of an air pump of the piston type, the other by means of a fan. A higher vacuum can be produced with the pump; and yet a very high vacuum is not needed: in fact, it has several disadvantages. A strong vacuum is hard on the rugs and carpets, or any cloth which is being cleaned.

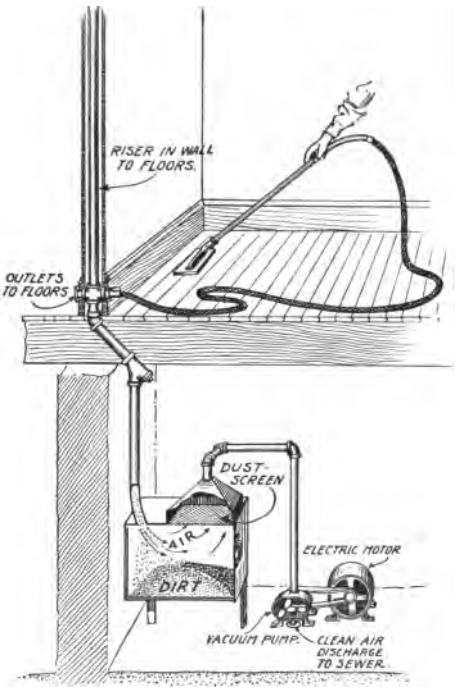


To show the principle of vacuum cleaning.

The principle of vacuum cleaning is easily demonstrated by holding the end of a glass tube near a loose ball of paper (*C*) and drawing up the piston (*A*). A vacuum is produced in the tube, and air rushing into the tube pushes the paper along with it. By making the opening (*O*) smaller by using a stopper with a small tube, sand may be forced into the tube, and if a piece of muslin cloth (*m*) is fastened over the inside of the stopper near the end of the larger tube, this will hold the sand and dirt which enters, but will allow the air to pass on. This illustrates the use of the bag for holding the dirt in the pump cleaners. In the fan cleaners, however, the dirt and air are blown

into the bag. The dirt is held here by the tight, close mesh of the cloth, but the air passes out into the room again after being filtered through the cloth.

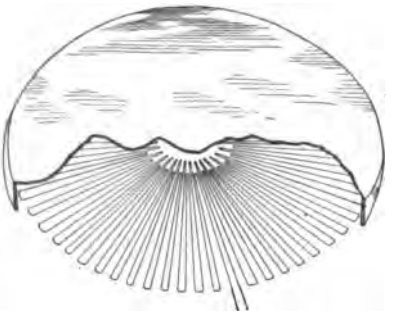
For thorough cleaning a vacuum of $\frac{1}{10}$ to $\frac{1}{7}$ of an atmosphere is desirable, but such a high vacuum makes the tool stick to the carpet and causes rapid wearing. For ordinary sweeping where it is desired to remove only the surface litter, a vacuum of $\frac{1}{15}$ of an atmosphere is sufficient. The low vacuum machines are termed "*vacuum sweepers*" by some, and the high pressure machines "*vacuum cleaners*." There are numerous hand-driven vacuum sweepers on the market. These give a lower vacuum, as a rule, than the electrically driven ones, and yet they are satisfactory for superficial sweeping. Carpets and rugs cleaned by "sweepers" need removal and beating occasionally.



Vacuum cleaning system.

Electric heating devices. — Many modern homes now are equipped with electric toasters, grills, coffee percolators,

chafing dishes, heating pads, curling irons, even with water and room heaters, and electric ranges. However, the electric flat iron is by far the most popular electric device so far introduced into the home. The principle of electric heating is practically the same in all of them. All conductors resist the flow of electricity. The electrical energy used in overcoming the resistance becomes heat. Some metals, like German silver and nichrome, offer much greater resistance than copper does. For that reason a short length of nichrome wire would give as much heat as a much longer copper wire of the same diameter. It is advantageous then to use a wire of very high resistance in heating devices where the heat is produced by electricity. You remember when studying about electric lights how a long wire was heated by an electric current. When the wire is in position in the base of a flat-iron it is covered with an enamel which is baked on so that the wire cannot move out of position or touch other parts of the wire. The heating element of the coffee percolator and other devices is made essentially in the same manner. The electric iron should have a switch



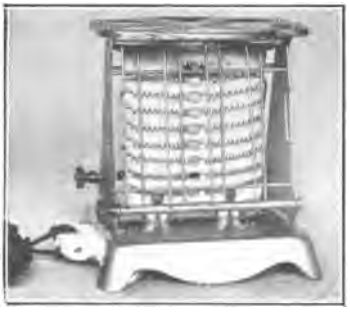
Showing the resistance wires in an electric stove.

Electric heating pad.

close to the iron, also a pilot light on the wall socket where it is attached. This pilot light will always glow

An electrically prepared meal. What heating devices do you see?

when the current is left on. Many fires are caused every year by carelessness with electric irons. The pilot will suggest to you the danger, and you will be less likely to



Electric toaster.

Electric iron.

omit turning it out when you leave it. It is a good habit to form always to disconnect at the socket.

The score card. — This score card will help you to become efficiency experts in your own homes. Mother could be saved a good deal of labor by the introduction of some of the machines mentioned here and no doubt your home life would be much pleasanter if some of the devices listed here were added to your own list. The list is incomplete, so space has been given for you to credit others. If you have a number of them, talk with your teacher and see if you can substitute some you have for others you do not have which are mentioned on the card.

REFERENCE BOOKS

Barber, *General Science*, Chapter X. Henry Holt and Company.

Caldwell and Eikenberry, *General Science*, Chapter XIX. Ginn and Company.

Clark, *An Introduction to Science*, Chapters XXII, XXIII, XXIV. American Book Company.

Clark, *The Care of a House*, Chapter XI (Teacher's use). The Macmillan Company.

Collins, *The Book of Electricity* (Wiring project). D. Appleton and Company.

Fall, *Science for Beginners*, Chapters XXX, XXXI, XXXII. World Book Company.

Hessler, *The First Year of Science*, Chapter VIII. Benj. H. Sanborn Company.

Hodgdon, *Elementary General Science*, Chapter XI. Hinds, Hayden, and Eldridge Company.

Jameson, *The Compass, the Signpost of the World.* Taylor Instrument Company, Rochester, N. Y.

Shafer, *Everyday Electricity*. Harper and Brothers.

Van Buskirk and Smith, *The Science of Everyday Life*, Project XVI. Houghton Mifflin Company.

Woodhull, *Electricity and its Everyday Use* (For projects). Doubleday, Page and Company.

SCORE CARD. DEVICES FOR CONVENIENCE AND LABOR SAVING IN MY HOME

	Score	
	Perfect Score	My Score
Electric fixtures		
Doorbells	2	
Telephone	5	
Vacuum cleaner	3	
Adjustable fixtures for reading	2	
Electric iron	1	
Electric cooker or heater	1	
Other devices (name them)	1	
Cleaning helps		
Carpet sweeper	2	
Dustless mop and dusters	1	
Washing machine or vacuum suction washer	2	
Clothes wringer	1	
Gas iron	1	
Wall ironing board	1	
Other devices (name them)	2	
Kitchen helps		
Fireless cooker	2	
Gas, electric, or blue flame stove	3	
Dishwashing machine	½	
Dish drying rack	½	
Bread mixer	½	
Meat chopper	½	
Egg beater	½	
Steam cooker	½	
Ice cream freezer	½	
Knife sharpener	½	
Other devices (name them)	1	
Other helps		
Sewing machine	5	
Electric motor or water motor for machine	3	
Other devices (name them)	2	
Tools and workroom		
Tool box and full set of tools	3	
Carpenter's bench	1	
Proper workroom	1	
TOTAL	50	

CHAPTER XXIII

HOW ELECTRICITY IS CONTROLLED IN OUR HOMES

Problems. — 1. *To determine how electricity is produced and controlled.*

2. *To find out what effect different lengths and sizes of wire have on the electric pressure and current.*

3. *To find out how the house is protected from excessive currents.*

4. *To learn how to read the electric meter.*

Experiment. — 1. Make a wet cell and show presence of an electric current.

Project I. — To install a night light in my bedroom.

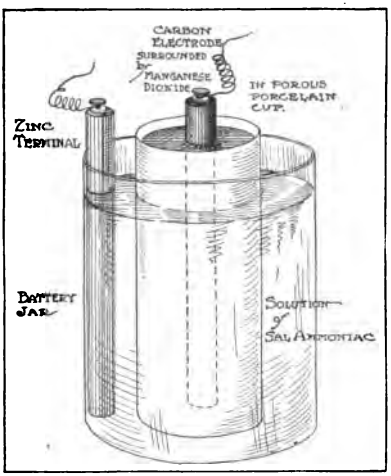
1. Purpose of the light?
2. How will you arrange wiring? Locate battery, switch, and lamp. Make plans of connections.
3. What materials are needed? Cost?
4. Install the light system and make a report on it.

Suggested Projects.

1. The transformer vs. dry cells to operate a doorbell. Find the cost of a doorbell transformer for use on electric light circuit, and cost of operating it. Find cost of operating doorbells on dry cells. Considering cost and convenience of uninterrupted service, which system would you recommend ?

2. Find the cost of operating various electric devices per hour. Learn how to measure small amounts of electric power by timing the revolutions of the dial in the wattmeter.

How electricity is led about in the home. — Although electricity has become a valuable servant and a cheap one where water power is available, yet it is a dangerous servant as well. We have often heard of fires that were caused by crossed wires making a "short circuit" or by accidents from electric wires of heating devices, or of people shocked to death by receiving a charge of electricity in their body. We know that the wires which carry electricity must be carefully guarded by a layer of what we call *insulating* material, that is, something that will not readily conduct the electricity. We have all learned enough about the conduction of heat to know that some materials are good and some are poor conductors. Likewise certain metals will conduct electricity, while other substances, like rubber, will not conduct it, hence the latter are used in insulation.

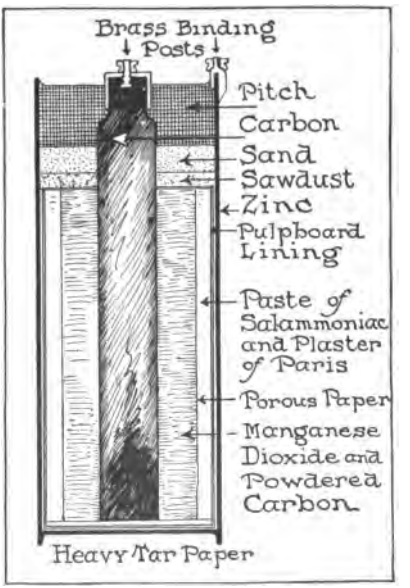


The sal ammoniac cell.

Current electricity. — If we rub wax rapidly with a piece of woolen cloth we can *electrify* it. The wax is then said to be *charged* with electricity. A charged body such as this, is one in which electricity is at rest. To be sure, the amount in the wax is very, very small, but if we were to connect two oppositely charged bodies, negative and positive, with a good conductor, such as a metal wire, elec-

tricity would flow for just an instant from one body to the other. Electricity in motion as this is, is called *current electricity*. This is the kind of electricity which we use in ringing our doorbells, in running our motors, and in lighting our homes. We have all seen what electricity will do, and now we will try to understand how to produce it, and some other things which we can do with it.

Electric cells. — You may have heard the terms, *dry cell* and *wet cell*, and doubtless some of you have seen them in your homes, as these two kinds of cells are used to ring electric doorbells. The wet cell is made by nearly filling a jar with a saturated solution of *sal ammoniac*. In this are suspended side by side, but not touching each other, a large *carbon* plate and a *zinc* rod. Electricity is formed at the expense of chemical energy, and the zinc rod which is destroyed must be replaced from time to time.



Section of a dry cell.

In the dry cell, the zinc used is placed on the outside of the cell while the carbon is a large rod in the center. Between these are the chemicals, a paste of sal ammoniac being placed next the zinc, and a layer of *manganese dioxide* around the carbon. Dry cells, because

they are more convenient to handle, have come to replace to a large extent the wet cell in our homes.

What produces the electric current? — When an electric cell has been used for a long time, it may refuse to produce any more current. In the case of the wet cells, you will very likely find that one of the plates in it has been used up. This suggests that some vigorous chemical action has taken place in the cell between the solution and the plates. This is true. The cell is really a device by which energy resulting from this chemical action in the cell is changed into electrical energy.

Experiment. — To make a wet cell and show presence of electric current.

Materials: Carbon. Zinc. Jar for sal ammoniac cell. Sal ammoniac. Electric bell or compass. Wires.

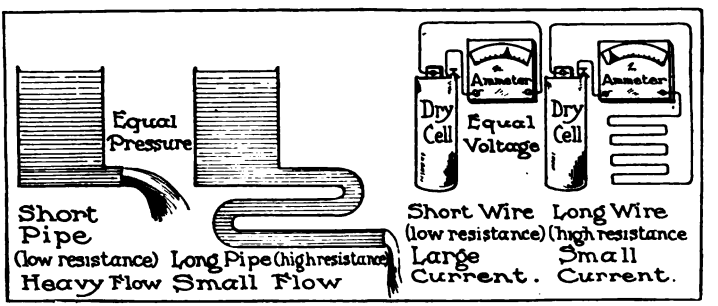
Method: Fill the jar with water to the mark and add sal ammoniac and stir. Continue adding sal ammoniac until a saturated solution is obtained. Put zinc and carbon in cell. Join wires to poles. Test to see if a current is produced by joining an electric bell in circuit or test wire of closed circuit with compass. How can you detect a current in a wire by means of a compass?

Result and Conclusion: What is the result? What are the essentials of a wet cell?

Wire resistance to electricity. — Anybody knows that if he wants to empty a tank of water a short pipe would empty it quicker than a long one of the same diameter. This is explained by the fact that a long pipe has more surface to rub against the flowing water, and this produces friction, thus allowing less water to get out in a given time. There is a very close parallel to this in the case of electricity passing through wires. If you connect the poles of one cell with a long wire and then the poles of the other cell with a shorter wire of the same diameter, the electricity will be discharged through the shorter wire more

rapidly. The reason for this is that the longer wire offers greater resistance to the current, so that less current flows; but as in the case of the tank of water, the current will flow for a longer time.

You also know that a pipe of large diameter will empty a tank of water much quicker than one of small diameter. A large tube (or pipe) carries a larger current of water than a small one. Just so with electric currents.



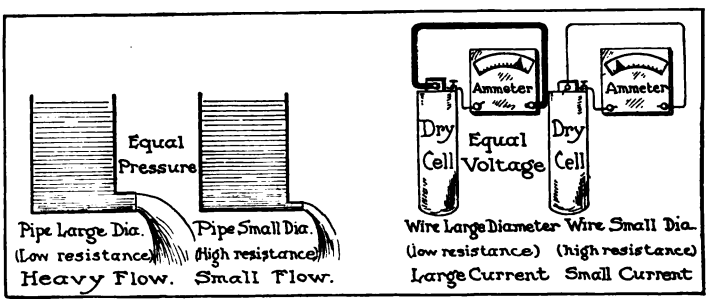
Water analogy: short and long wire resistance.

The wire with a large diameter permits a larger flow of electricity than one of small diameter.

Electrical pressure. — Suppose you have two tanks of water, one holding a large amount, and the other a small amount and that the water in them is kept at the same level. The water running from the faucets at the bottom will have the same pressure just so long as the level is maintained evenly in the two, and if the openings of the two faucets are of the same size, equal streams or currents of water will flow from them. The electrical pressure (called *voltage*) is independent of the size of the cells used. The cell of a small flashlight may have just as high pressure or *voltage* as does a common dry cell which has a

pressure of about 1.5 *volts*. A volt is the unit used in measuring electric pressure, or the force which causes electricity to flow through a conductor. An instrument for measuring voltage is called a *voltmeter*.

Electric current. — If we use our tank again for comparison, we shall see that water pressure alone will not tell us how great a flow of current may be obtained. The size and length of the pipe help to determine this, because they regulate the resistance, and resistance is one factor which determines the amount of water which flows.

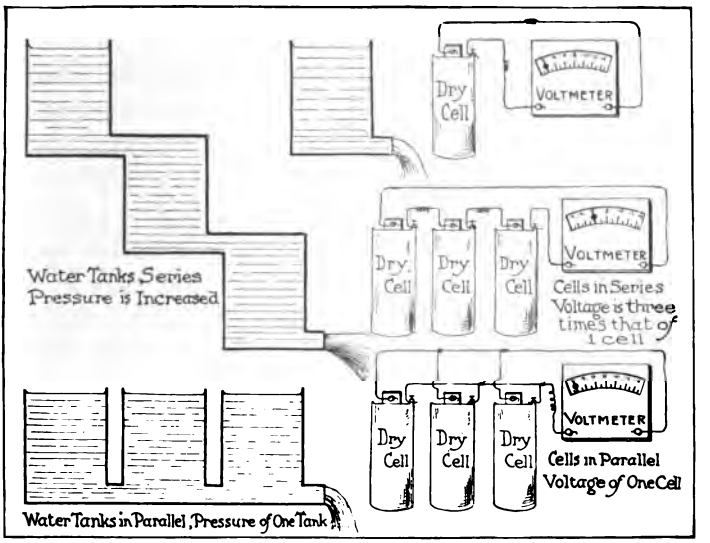


Water analogy: relation of current to resistance in large and small wires.

This also holds in a similar manner with electricity. If we have the poles of a cell connected by a wire of small resistance, a large current will flow through it, but if the resistance be great, a small current will flow. The unit for measuring an electric current is the *ampere*, so named after a French scientist. The instrument by which this current is measured is the *ammeter*.

How to join cells for use in the home. — There are two ways in which we may join cells together so that we can overcome resistance offered by wires. These are in *series*, and in *parallel*. We can understand these terms best by referring again to our water tanks. Suppose we have three

tanks of water at the same pressure, and connect them so as to get a water column three times as deep as that of a single tank. The water pressure will be three times that of a single tank. If we join three cells in series, that is, zinc to carbon, and connect a voltmeter in the circuit, we shall find three times as much pressure recorded as when



Water analogy to illustrate joining cells in series and in parallel.

a single cell is attached to the voltmeter. A high pressure (high voltage) will give us a larger current (in amperes) through the bell, motor, or light than we can get from the low pressure. When long wires are used in connecting an electric bell greater voltage is required to overcome the resistance of the long wire. This increased voltage can be obtained by putting in one or two more cells joined in series. A bell can be made to ring louder and a motor to run faster by this same method.

When we join our three tanks of water at the same level, we increase the capacity to furnish a current of water, although it has no greater pressure than the single tank. We may join three cells *in parallel* by connecting all the zinc poles to one wire, and all the carbon poles to another wire, then we join these two wires where we wish to use the current. If we attach a single cell to the voltmeter and read the voltage, and then later attach three cells joined in parallel to the voltmeter and read the voltage, we find it to be the same. Any number of cells joined in parallel have just the same voltage as a single cell. With the same size of opening for the single and the triple water tanks the water would flow from the triple tank for a longer time. It has a larger reservoir, so with the cells joined in parallel, if the voltage of one cell gives all the pressure you need, you can get much longer service from several cells joined in parallel than you can from one cell. These explanations should serve to make it possible for you to now use the batteries in your own home intelligently.

The life of a cell. — If you have a large outlet to a tank of water, it will quickly drain the tank. The less resistance you have in the circuit of an electric cell, the greater will be the flow of the current, and since the capacity of a cell is limited, its life will be shortened. The practice of connecting two poles of a cell by a short piece of metal quickly spoils the cell. If you wish your cell to work for you for a long time, be sure not to allow any "short circuits."

What is a "short circuit"? — We have all used the term "short circuit," and now let us try to understand fully what it means. The circuit of electricity is the complete path which the current must take from the cell

out around the wire, through the bell, or other instrument, and back to its starting point. Let us, for example, take the lighting system in our home. Current is brought into the house by one wire, and returns to its source by another. If in the diagram, *A* and *B* connect our house circuit with the city supply, when the switch is closed we are able to light any one or all of the lights *L*, *L'*, and *L''*. These lamps have a high resistance to electricity, and allow not more than one to three amperes of current to flow through the circuit. Now suppose the bare ends of the wires *C* and *D*, which have low resistance, are brought together. This "short circuit" would reduce the resistance several hundred times, and the current would be increased enormously.

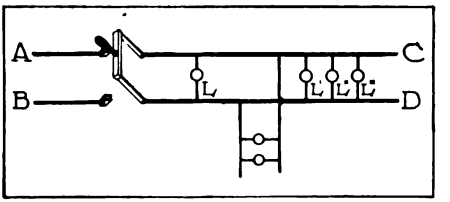
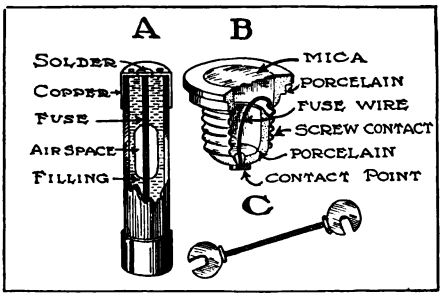


Diagram of lighting system.

There is a real danger from short circuits. Not only may the insulation on wires be burned off, but the building may be set on fire. If any part of the wire *AC* is connected metal to metal with any part of *BD*, or if the two separated metal parts of the lamp circuit be joined by a piece of metal, a short circuit results, with its great increase of heat and corresponding danger from fire. When the dry cell is "short circuited" there is much less danger from fire than in the case of the electric light circuit, because the cell has a very small capacity. Yet this cell will heat a short length of small iron or german silver wire red hot, and so might be a source of danger.

Fuses. — If we were to take a number of different metals and expose them to heat, we would find that some of them

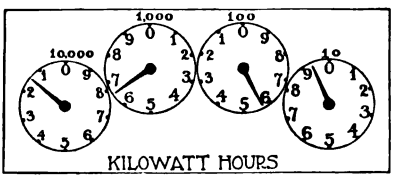
melt at a much lower temperature than others. Lead, for example, melts very readily. If you have seen the plumber solder pipes, you have noticed that he has a copper instrument which is used to melt the solder, so you know that red hot copper can melt solder. Such low melting metals are used in making *fuse wires*. If a fuse wire is made a part of the electrical circuit in a house, it would evidently melt if heated to a point much below that which would melt the copper wires carrying electricity. Such a wire placed in the house circuit is known as the *fuse*. If a short circuit is produced, the fuse instantly melts, and thus the electricity is cut off from the house, and danger from fire prevented. If we have electric lights in our home, we should all know the location of the fuse box, and we should understand how to put in the fuse plugs in case they burn out. Of course, we must take care first to *turn back the switch*, thus cutting off all the electricity from the house, before we attempt to do this.



Fuses: *A*, Cartridge fuse; *B*, Socket fuse; *C*, Link fuse.

Measuring electricity. — Each one of us should learn to read the dials on the ordinary electric meter, which is part of the equipment of every house that takes its electricity from the city supply. The meter is called the *wattmeter*, and the readings are made in *kilowatt hours*. For example, if we have ten lamps, each marked twenty-

five watts, and they are all lighted for an hour, we would then be using 10×25 or 250 watts an hour, and in five hours this would be 5×250 or 1250 watt hours. The *watt* is the unit by which we measure electrical energy. One thousand watts make one *kilowatt* and one kilowatt used for one hour equals one *kilowatt hour*. Electricity for the ten lamps, using 1250 watt hours or 1.25 kilowatt hours, would cost, at twelve cents per kilowatt hour, fifteen cents per hour. A study of the diagram shows that of the four dials, the one to the left moves the least, while the one to the right moves the fastest. The four dials indicate thousands, hundreds, tens, and units. Study the diagram. If the thousands hand is between 1 and 2, it will indicate 1000; if the hundreds hand is between 6 and 7, it indicates 600; if the tens hand is between 5 and 6, that will be 50, and the units hand, between 9 and 0, is read 9, making a total of 1659 kilowatt hours. If the previous reading had been 1610, that would mean that we have used 49 *kilowatt hours* since the meter was last read. We have already shown under the chapter on lighting some ways to reduce the electric light bill through the use of the tungsten lamps, but if our meter bill seems high, we should inquire into the cause. The large bill may come from some leakage, from a forgotten light in a closet or attic left burning, from defective wiring which may allow a current to flow when no lights are in use, and rarely from an error in the meter itself, or in the reading of the meter by the man sent from the electric company.



Wattmeter dials.

REFERENCE BOOKS

Bachman, *Great Inventors and Their Inventions* (Edison). American Book Company.
Baker, *Boys' Second Book of Inventions*. McClure Phillips Company.
Book of Knowledge, *Articles on Electricity*. Grolier Society.
Butler, *Household Physics*. Whitcomb and Barrows.
Caldwell and Eikenberry, *General Science*, Chapter XVII. Ginn and Company.
Clark, *Introduction to Science*, Chapter XXIV. American Book Company.
Clark, *The Care of a House*, Chapter XI (For teachers). The Macmillan Company.
Croft, *Wiring for Light and Power* (For teachers). McGraw Hill Book Company.
Knox, *All About Electricity*. Funk and Wagnalls.
Lynde, *Physics of the Household*, Chapters XIX, XX, XXI. The Macmillan Company.
Morgan, *The Boy Electrician* (For projects). Allyn and Bacon.
New International Encyclopedia, for lives of great discoverers of electricity. Dodd, Mead, and Company.
Romance of Modern Electricity. J. B. Lippincott Company.
Tappan, *Wonders of Science*, "Interviews with Edison." Houghton Mifflin Company.
Van Buskirk and Smith, *Science of Everyday Life*, Project XII. Houghton Mifflin Company.

PART VII. RECREATION IN THE HOME

CHAPTER XXIV

INDOOR RECREATION

Problems. — 1. *To learn the nature of sound and the relation of our voice and ears to sound.*

2. *To learn simple principles underlying music and musical instruments.*

3. *To cultivate the habit of reading good books.*

4. *To see how to get the most home enjoyment in stories and games.*

5. *To learn some ways to have fun with mechanical and electrical toys.*

Experiments and demonstrations. — 1. To show that sound is due to vibration.

2. To demonstrate static electricity.

Project I. — To UNDERSTAND THE MECHANISM OF THE PIANO AND THE PIANO PLAYER.

1. The wires, relation of sizes, lengths, tension. How tuned?

2. Key action? Diagram to show it. Keyboard? Octaves?

3. Pedals. Action and control?

4. Player — pump — air pressure or exhaust. How does air control key action? Use of the music roll?

Suggested Projects.

1. TO LEARN HOW TO BE A VENTRILOQUIST.
2. TO BUILD A CANTILEVER BRIDGE WITH A MECCANO OUTFIT.
3. TO LEARN TO PLAY SOME MUSICAL INSTRUMENT.
4. TO LEARN TO SING OR TO TELL A STORY WELL.
5. TO START A STAMP COLLECTION AND SPECIALIZE IN THE STAMPS OF SOME ONE COUNTRY.
6. TO LEARN TO DO ELECTROPLATING.

The place of recreation in our lives. — We hear a great deal nowadays about the eight-hour day. The average day of the working man or the business man or woman should give eight hours for work, eight hours for sleep, and eight hours for other duties of life, including recreation. In our school day, even more time is allowed for play. But much of this time is spent away from home. We are getting far too fond of spending time away from home, especially in the evenings. How much better it would be for every boy and girl to feel that two or three hours in the evening should be spent in the family circle. Too many movies and not enough home life are the choice of the average boy and girl of to-day. We usually have access to the well-lighted reading room of the public library. But nothing can take the place of home, and the remembrance of the pleasant evenings spent before the open fireplace, or playing games, or reading around the comfortable lamp in the living room, should be the heritage of every boy and girl who reads this book.

Sound in relation to our home life. — Have you ever stopped to think what our home life would be without sound? No mother's or father's voice, no conversation at the table, no music, vocal or instrumental, no phonograph, none of the hundreds of pleasant and interesting events

which follow the use of our voices, for *withou sound* means *without voice.* You will be glad, now, to get a little information about sound in its relation to human beings.

What is sound? — We know in a general way that we make sounds by means of certain cords in our throats,

Enjoying life at home.

called the *vocal cords*, and that sounds affect our ears, which in turn communicate them to the brain, and we get the sensation we call sound. But this does not explain how sound originates.

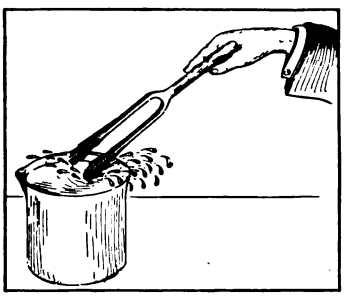
Experiment. — To show that sound is due to vibration.

Materials: Tuning fork. Pith ball on end of a thread. Glass of water.

Method and Results: Strike the prong of a tuning fork on a block of wood. Rest the handle end against the table. Let the pith ball suspended by the thread come in contact with the prong. Result? Strike the prong again and touch the surface of the water with it. Result? Pluck a stretched string. Touch with the pith ball. Result?

Conclusion: Do these bodies produce sound except when they are vibrating? How does a body produce sound?

When the alarm clock goes off in the morning, it makes no difference what part of the room it is in. Sound travels from it in all directions. If we obtain a tuning fork, an instrument which gives a musical tone, we shall be able to learn something about how sound is produced. If we strike the prongs of the fork on a block of wood, we are all able to hear the sound, although we cannot notice that the tuning fork looks any different than it did before it was struck, but if we hold a pith ball suspended from a string so that it touches the prong of the fork, after the fork has been struck, we notice that the pith ball moves violently away from the fork, as if struck by a blow. If we now stick the end of the fork into a vessel of water, we find a fine spray of water thrown from the surface. Evidently the fork is in quite rapid motion. As a matter of fact, it is vibrating several hundred times a second, and in vibrating, it strikes the air just as it strikes the water, and sets up little waves in the air. Just as waves move on the surface of water when we drop a stone in, becoming wider and wider as they move away from their source, so a body that makes sound, as the tuning fork, sends these waves off into the air. Only we must remember that instead of the waves moving, as on the surface of the water, in one plane only, these are moving away in all directions from the sounding body, each wave making a hollow sphere in the air.

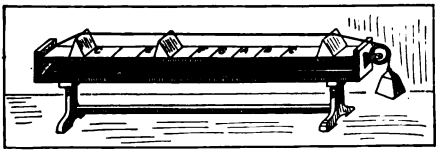


How to show that a sounding tuning fork is in motion.

Our voice. — A study of the figure will show us the location of the vocal cords, which are instrumental in producing sound. They are composed of two thin structures stretching from front to back across the voice box, near the top of the larynx. They are attached to the side walls. By means of muscles the tension of these cords may be changed and the size of the opening between the two outer edges may be made larger or smaller. In deep breathing, for example, they lie flat against the side walls of the larynx, thus allowing a full entrance of air. But when we make a sound they come very close together so that only a narrow opening is made between them. The tightly drawn cords are set into vibration by the passing air, and sound results.

Vocal cords.

Differences in the pitch of the voice. — A child's voice is shrill or high pitched. This is because the larynx is narrow and the vocal cords are short. It is a well-known fact that long wires or strings, when vibrating, give a much lower and deeper tone than do short strings. This is easily seen in picking the mandolin or banjo. If you put your fingers on the frets, making the string shorter, it gives a note of higher pitch. When a boy's voice is breaking or changing, it means there

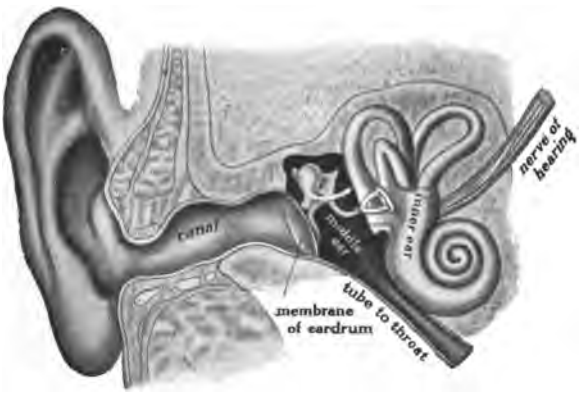

The pitch of a string is raised by shortening the wire and by increasing the tension on it.

is a sudden growth of the larynx, and in consequence, a lengthening of the vocal cords. This change is so rapid that there is an uncertainty in the boy's control of his vocal cords, and the break in the voice occurs.

How we talk. — Human speech seems very wonderful, and yet it is all accomplished after we have learned how to control the voice with absolute unconsciousness on our part. When we speak in a monotone, all of our words are of the same pitch, and yet we can distinguish differences in the sound of the different words. This is due to the quality of sound. As the sound waves pass through the mouth, they are changed in quality by movements of the tongue, soft palate, cheeks, jaws, and lips. A study of your own voice before a mirror while you make the sounds *a*, *e*, *i*, *o*, and *u*, will show you that in each of these sounds, a different position of the parts of the mouth and throat are assumed. It is excellent practice for any one who is troubled in enunciation to thus stand before a mirror and practice making these sounds, for it is only by practice that our mouth parts unconsciously get the habit of forming sounds correctly, and thus we learn to speak clearly. Get this habit of clear enunciation while you are in school, and it will remain with you as a good habit through life.

How we hear. — Sound and speech would not be of much use to us if we could not hear. The ear is far too complicated and delicate an organ for us to understand at this time, although a study of the accompanying diagram will give us some idea of how sound is heard. The outer ear, which is simply an organ to help gather the sound waves, leads by means of a tube into the middle ear. This is separated from the outer ear by a delicate

membrane. If this membrane is broken, hearing is impaired, and therefore children should be very careful not to stick a pointed instrument into the ear, and if anything gets into the ear, they should not try to get it out themselves, but should get help from some one who knows how to handle the ear. In the middle ear are three tiny bones. These serve as a bridge to carry the sound waves from the outer ear into the inner ear. Waves hit against the membrane



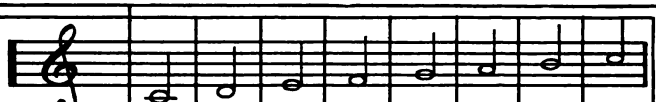
Parts of the ear. Notice the three little bones in the middle ear.

and cause it to vibrate, and are transferred to the middle ear. Here deep in an opening in the bone of the skull is an instrument a thousand times more delicate than the most wonderful piano in existence. This instrument receives the sound waves and transfers them to the brain.

The ear is also a balancing organ, and in many lower animals has this function only. Our equilibrium is maintained by means of three so-called *semi-circular canals* which are set into the opening at different angles. Those men who wish to become aviators must have a perfect

sense of equilibrium, and if their semi-circular canals are not in excellent condition, they cannot enter this arm of government service.

Music and noise. — We are all aware of differences in the sounds that come to the ear which cause us to say, " This is noise," or " This is music." These differences are due to definite pitch relations and periodic movement of sound



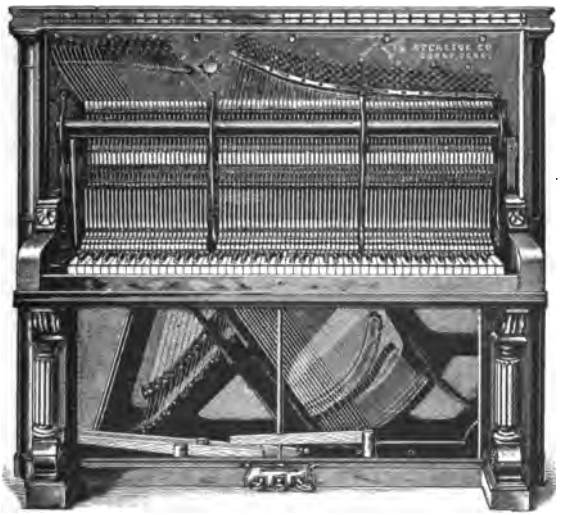
Name	do	re	mi	fa	sol	la	ti	do
Letter	C	D	E	F	G	A	B	C
Number of Vibrations per second beginning with middle C (piano)	258.7	290.3	325.3	345.3	387.6	435	488.3	517.4
Standard of the Physicist	256	288	320	$341\frac{1}{3}$	384	$426\frac{2}{3}$	480	512

The musical scale.

waves. The beating of a tom-tom and the monotonous chant of a savage in his war dance are periodic, and have a definite pitch, but they are not pleasing to our ear, hence they cannot be classified as music to us, although to the savage who makes them and enjoys them, they are music.

The musical scale. — Our music is built up on a series of sounds having definite ratios of vibration. This is called the musical scale. A study of the diagram below shows the staff, with the names of the notes or letters

given these notes, with the number of vibrations that each makes. This series of tones, which is used for all kinds of musical instruments the world over, is known as the musical scale. Each higher tone in the next scale will have twice the vibration rate of that of the corresponding letter in the scale shown in the diagram, and each of the

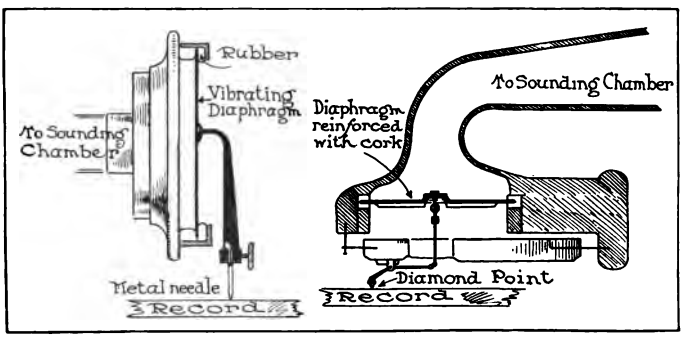


An instrument with many strings. Can you locate the strings which give the low tones?

next lower scale will have half the vibration rate of the corresponding tone in the scale shown. There are on the piano and organ keyboard black keys which have intermediate rates of vibration. These are the so-called sharps and flats, and without these notes modern music would be impossible.

Stringed instruments and how they make sound. — We have already alluded to the fact that a note of low pitch is caused by the vibration of a long string, while

notes of higher pitch are caused by the more rapid vibration of shorter strings. In stringed instruments, such as the banjo, guitar, mandolin, violin, and cello, the musical scale is made by cutting down the length of the string by means of shortening it with the fingers. In the case of the piano and harp, the strings are all made of varying lengths, each producing its own tone. Just as we found in changing the shape of our mouth and tongue we could produce different qualities of tone, so the instrument



maker produces different quality by making his instruments in different shapes.

The phonograph. — The phonograph has become a very important part of our home life, for though relatively few of us can make music, most of us enjoy it. The phonograph is a musical device for reproducing sounds. The original sounds are recorded as a fine wavy line on a wax cylinder or plate. The records we buy are duplicates of this original, or *master record.* The reproducing mechanism has a diaphragm capable of very delicate vibrations. This is connected with a needle which rests on the

record. When the record is set in motion, the needle follows the fine wavy line and is made to vibrate to correspond with the vibrations of the original sound waves. These vibrations are communicated to the diaphragm, and this causes sound waves in the air, which come to us as reproductions of the original sound.

Good reading and what it means. — We have already said that life is made up of bundles of habits. We form habits by doing things when quite young, and you are now at an age when you can form them most easily. Why not use some of the time you spend in recreation in getting the habit of reading good books and good magazines? Far too many boys and girls limit their reading to the daily newspaper or some of the various cheap weekly and monthly magazines. Life will be far richer to you if instead of feeding your mind upon trash, you use something which will be of use to you later. It is simply a matter of habit whether you read a number of poorly written stories with very little of real interest in them, or whether you form the habit of reading books that are really worth while. What could be more absorbing, for example, than Stevenson's "Kidnapped" or "Treasure Island," Scott's "Ivanhoe," or Kipling's "Captains Courageous"? Such books rank high as literature and at the same time are as thrilling as you may desire. Some other stories of interest to boys and girls are as follows: Kipling's "Just So Stories," and "Jungle Books," Numbers One and Two; Poe's "The Gold Bug"; Carroll's "Alice in Wonderland" and "Through the Looking Glass"; Arnold's "Tom Brown at Rugby"; Scott's "Ivanhoe" and "Guy Mannering"; Dickens' "Tale of Two Cities," "Nicholas Nickleby," and "Pickwick Papers," the latter

if you want a good laugh; Lanier's "King Arthur"; Pyle's "Robin Hood"; Blackmore's "Lorna Doone." For real fun read "Uncle Remus" and "Peterkin Papers"; Lear's "Nonsense Rhymes," and even "Little Black Sambo." Girls will enjoy "Peter Pan," and Barrie's "Little Minister," or "Sentimental Tommy," and we never get tired of stories such as "Don Quixote" and some of Shakespeare's plays. As for magazines, why not make a rule of reading articles that interest you from some good weekly such as the "Independent" or the "Outlook," and boys' and girls' magazines such as "Youth's Companion," "Saint Nicholas," and boy and girl scout magazines. Boys will certainly enjoy "Popular Science," and "Popular Mechanics." There are always plenty of good monthlies to be obtained from the libraries and one should get the habit of reading the stories in the "Century" and "Harpers" rather than those of the many trashy illustrated magazines that cover our news stands. To sum up, learn to like good literature rather than trash, and get the habit of reading at home.

An evening at home. — Have you ever thought that the whole of society as we know it in this country and in all the civilized world is built upon the family as a center? While this book has treated of the family in its relation to the home, the next book will concern itself with you and your family in relation to your neighbors, or what we call society. But society would be of little value were it not for the training we receive in our home life, for after all, we cannot do as we like in this life. We are not individuals living alone. Every act of ours which is selfish may have as a consequence some influence over another person's life. At home we obey mother and father be-

cause we love them. We do not think, perhaps, that the result of our disobedience might bring annoyance or even disgrace upon them or others in the family, but such is usually the case.

In our ideal home father and mother will join in many of our social activities. An evening gathering around the dining table, or perhaps under the cheerful glow of the lamp on the center table in the living room should be a time when we learn to enjoy each other's society through conversation, story-telling, and games. Here again habit may play a part. Get the habit of telling the funny things that happen to you during the day at school, or elsewhere. Let father and mother have a good laugh over some of your pranks or jokes, for it is good hygiene to be cheerful at the table. An interesting habit for the family to form is that of picking over some of the interesting happenings told about in the newspaper, or perhaps you have learned some new science facts in school and are reading up for a home project. Why not let father and mother know about it? They are sure to be interested. Sometimes a good charade in which two or three members of the family act out some word by syllables will be good fun and will sharpen your wits. An interesting form of home recreation is to try to act out some little story you have read with brothers and sisters.

Puzzles and games. — Perhaps one of the best ways of spending our recreation time in the evening is in playing games. There are a great many kinds of games, and this is not the place to tell how to play them, but games of skill are certainly the most fun. Checkers, dominoes, and halma are all good games which train us to think quickly, for they are an interesting kind of mental arith-

metic. Crokinole, carroms, ping pong, and table tennis, or games in which marbles are used, and above all, pool and billiards, are interesting games of skill in which the eye and the hand play important parts. Chess is an interesting game, and one that requires so much skill that many volumes have been written on how to play it, and it has been called the royal game. Jig-saw puzzles are fun to use when others wish to read and you have to play alone. They are in addition easily made, for any boy can afford a jig-saw, and a jig-saw puzzle can easily be made by pasting a colored picture on a flat board and then cutting the picture up into various patterns.

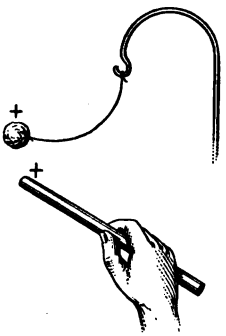
Stamp collecting. — Another interesting home amusement is that of stamp collecting. Not only is it good fun to have a collection of stamps, but it also may teach us a great deal about the geography, money, and even the history of the different countries of the world. While no one of us can expect to have a very large collection, yet it is quite easy to begin one, and you will soon discover that many grown-ups who have kept their boyhood collections are always glad to start the young collector with a present of a few stamps. Wholesale houses which deal with other countries are sure to receive stamps, and usually they can be had for the asking. One need not spend much money in this pastime, for there are always many other boys and girls who will collect with you, and who will exchange duplicate stamps. A good way to enjoy stamp collecting is to form a small club which meets around in the homes of different boys and girls. Invite some older person who is interested to come in to your meetings and show you his collection. He will probably be glad to do it, and will tell you many interest-

ing things about stamp collecting and other countries. Sometimes you can have a stamp auction, or an exchange, and thus make an evening pass very pleasantly indeed. Be sure, if you have been given an old collection by some relative or friend collected years ago, that you do not give away or sell cheaply the one or two valuable stamps that may be contained in the collection. The best way to keep a collection is to buy a cheap blank book with places for the stamps and to have a catalog. In this way one can insert the stamps where they belong.

Mechanical toys. — Not all of us can afford some of the expensive mechanical railroad trains, boats, submarines, and airplanes that we see nowadays, but almost any boy can make a start by purchasing one of the many erecting devices found in the stores to-day, such as Meccano and Erecto. These are instructive as well as interesting as toys, because we can actually build some of the things that we see planned or read about, and if we cannot afford such toys, a few simple tools and a tool box will give us more real enjoyment than almost anything else, for who does not like to make things. It is for this reason that we played with blocks when we were younger, and boys and girls twelve to fifteen years old like to make things, too. Perhaps it is dolls' dresses, or it may be a model airplane and mechanical engines and boats; these are interesting because through the use of them we learn something about the real machines we shall meet in later life. Some boys have given to them year after year the various parts of a toy railroad, and in time will have tracks, stations, bridges, and turn tables, block signals, and switches, and models of steam and electric locomotives. These boys will study and understand the working and the

running of their railway system, and with their friends pass many happy hours "running a railroad."

Homemade electricity. — A great deal of fun may be had from a little further knowledge of electricity which can be made in the home. You have sometimes produced an electric spark when you "scuffed" your feet over the carpet in winter or rubbed the cat's fur the wrong way, or had your hair stand up in an astonishing manner when you brushed it. These are all caused by electricity. Many interesting things can be done at home with this electricity if the air is cold and dry. If a hard rubber fountain pen or a rubber comb is rubbed briskly with flannel it will attract small bits of paper or a pith ball supported by a thread. If the ball or the bits of paper become electrified, as they sometimes will after clinging to the rubber for a moment, they will be repelled and fly away from it.



An electrified rod repels the pith ball.

Experiment. — To demonstrate static electricity.

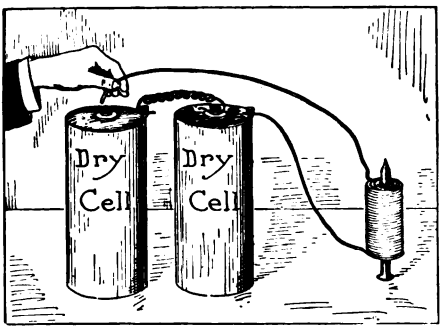
Materials: Hard rubber rod or stick of sealing wax. Two large rods of solid glass. Fur. Flannel. Silk. Pith ball.

Method and Results: Electrify the glass (previously warmed a little) by rubbing with silk. Support this on a wire stirrup supported by a thread. Electrify the other glass rod. Bring the charged ends near each other. Result? Rub the hard rubber with fur. Bring the charged end near the charged end of the suspended glass rod. Result? Hang a pith ball by a thread. Hold an electrified glass on one side of it and an electrified rod of hard rubber on the opposite. Result? Glass rubbed with silk is positively electrified. Rubber or wax rubbed with flannel or fur is negatively electrified.

Conclusion: What is the action between electrified bodies? When

a neutral body touches an electrified body the charge distributes itself over both bodies, so they are electrified alike. Explain the action of the pith ball when held between the glass and hard rubber.

Electrical toys. — There are several different types of toy electric motors. You will find it interesting to examine some of them to see if you can recognize the different types and find out how they work. A most interesting home project would be to build your own motor. Directions for this can be found in almost any good boy's book of inventions, such as "Home Made Toys for Boys and Girls," by A. N. Hall. There are many electromagnetic devices from which one may get a lot of fun, for example, an electric hammer can be made by winding a coil of wire around a pencil. Make the coil three inches tall, and wind about ten layers of No. 16 insulated wire. Remove the pencil. Connect one end of the coil to a battery consisting of one or more dry cells. Hold the coil an inch above the table. Place a large nail in the hole inside the coil letting the head of the nail rest on the table. Now attach the wire from the other end of the coil to the other pole of the battery, and the nail will rise in the coil. Break the contact, and the nail will fall, striking a strong blow on the table.



A toy electric hammer.

The use of electricity in working a home telephone or

telegraph outfit will be given when considering communication in the next book.

SCORE CARD OF MY INDOOR RECREATIONS

	Score	
	Perfect Score	My Score
Piano or organ	5	
Playing or singing by members of the family	5	
Victrola or piano player	5	
Have read at least five books listed in Chapter XXIV, pages 381–382	5	
Habitually read at least three standard magazines	5	
Talk over day's experiences and tell funny stories at meals	5	
Group games played in evenings, whole family taking part sometimes	5	
Skillful in at least two games mentioned in Chapter XXIV	5	
Collect stamps, or make collections of other objects; have a hobby	5	
Have made at least one toy mentioned in Chapter XXIV, or have completely dressed a doll, making all clothes myself	5	
Total	50	

REFERENCE BOOKS

Beard, *American Boy's Handy Book* (For projects). Charles Scribner's Sons.

Beard, *What a Girl Can Make and Do* (For projects), pages 227–235. Charles Scribner's Sons.

Bedell, *Practical Electroplating* (For projects). Published by author, Springfield, Mass.

Brownell, *General Science*, Chapter X. P. Blakiston's Son and Company.

Butler, *Household Physics*, Chapter IV (Sound). Whitcomb and Barrows.

Carrington, *The Boy's Book of Magic*. Dodd, Mead and Company.

Chemistry Sets, Electrical Sets, Erector Sets. A. C. Gilbert Company, New Haven, Connecticut.

Chemistry Sets, Chemcraft. Porter Chemical Company, Hagerstown, Maryland.

Clark, *Introduction to General Science*, Chapter XXXI. American Book Company.

Fall, *Science for Beginners*, Chapter XXIV. World Book Company.

Fisher and Fisk, *How to Live*, Chapter IV (For teachers).

Hall, *Home Made Toys for Girls and Boys*. Lothrop, Lee and Shepard Company.

Hessler, *First Year in Science*, Chapters VIII and IX. Benj. Sanborn and Company.

Hodgdon, *General Science*, Chapter XII (For projects). Hinds, Hayden, and Eldridge.

Kelley, *Three Hundred Things a Bright Girl Can Do*. Dana Estes and Company.

Lynde, *Physics of the Household*, Chapters XXVIII, XXIX. The Macmillan Company.

Meccano Outfits. Meccano Company, Inc., New York.

Sloane, *Electric Toymaking for Amateurs* (For home projects). Norman Henley and Company.

St. John, *Real Electric Toy Making for Boys*. Thomas St. John.

Tolman, *Hygiene for the Worker*, Chapter X. American Book Company.

Van Buskirk and Smith, *The Science of Everyday Life*, Project I. Houghton Mifflin Company.

Williams, *How it Works*, pages 227–309. Nelson and Company.

Winslow, *Healthy Living*, Chapter XVI. C. E. Merrill and Company.

CHAPTER XXV

OUTDOOR RECREATION

Problems. — 1. *To learn what games can be played in the home yard.*

2. *To find out what science principles underlie our common games and toys.*

3. *To see how a lens makes objects appear larger.*

4. *To understand how pictures are taken.*

5. *To learn the relation of our earth to other heavenly bodies.*

Experiments. — 1. Demonstrate gyroscopic motion with toy gyroscopic tops.

2. To show centrifugal force.

3. To show the processes of printing, developing, and fixing a picture.

Project I. — TO PLAN FOR UTILIZING THE PLAYGROUND OF THE HOME LOT.

1. Determine what space is needed for games which interest you.

2. Which games require permanent location because of the fixtures, and which allow the ground to be used for other games at times?

3. What will be the cost of the games? What ones can you make or arrange by yourself?

Suggested Projects.

1. MAKE A PINHOLE CAMERA AND TAKE PICTURES WITH IT.
2. TAKING AND MAKING PICTURES.

3. To make a box kite.
4. To make a sailboat that will sail into the wind.
5. To make a toy airplane.
6. To make a Russian ninepin set.
7. To learn twenty constellations.

The home yard and playground. — Fortunate indeed are the children who have a yard which is their own in which to play. In many cities no such thing is possible, and boys and girls must share with others the public playgrounds where they are found. But every home yard, no matter how tiny, ought to have some space devoted to play. For little children a sand box with its load of clean white sand gives pleasure the day long, and even grown-ups like to build miniature roads or tunnels, and fight battles with toy soldiers, in the make-believe land of the sand box. For older boys and girls, if there is not room for ball, croquet, or tennis, there is at least a place for the game of quoits, tether ball, or Russian ninepins, even in the back yard. Russian ninepins in particular is great fun, and requires a great deal of skill. Tops and marbles have been played by generations of small boys, yet never lose their interest. The top is also of scientific interest to us, for it represents what is known as *gyroscopic motion*. As the top spins, it resists the force of gravity. As you doubtless know, the instrument called the *gyroscope* is used in many ways, especially on large ships to prevent rolling in storms, in airplanes to keep them upright, and in the new type of marine compass.

The gyroscope.

Experiment. — To demonstrate gyroscopic motions.

Materials: A toy gyroscope.

Method and Results: Set the wheel in motion. How long will it spin with vertical axis? Set in motion and rest one end of axis on the wooden support, with a horizontal axis. If the wheel were not spinning would it stay in that position? Set in motion again. Take hold of one end of axis and quickly change from vertical to horizontal. Compare the resistance to this movement when the wheel is revolving to that when the wheel is still.

Conclusion: What are some laws of gyroscopic action suggested by these experiments? How can the gyroscope act as a stabilizer of ships and airplanes?

Darts, slings, and bows and arrows. — Any toy that can be made is of more interest than one we buy, and toys which allow us to play in competition with others so that our skill is matched against that of the other fellow, are most interesting of all. Long years ago dwellers on the earth used the sling, the dart, and bow and arrow as a means of getting their food as well as weapons for offense and defense. We all know the story of David and Goliath, and who has not read of the early days in this country when Indians not only shot their food, but also killed their enemies with a bow and arrow? Very briefly some of the science underlying their use may be mentioned here. For example, in the dart, or in the arrow, why do we have pointed tip, and feathers or pieces of stiff paper at the hind end of the dart or arrow? The *elasticity* of wood, metal, and cord is also strongly shown in the case of the bow. In the use of the sling, when we whirl the sling round and round before releasing the missile, we have a good example of *centrifugal force*. This is the force which would cause each one of us to fly off the surface of the earth as it goes whirling around in space were it not for an opposing force which holds us down, the force we call gravity.

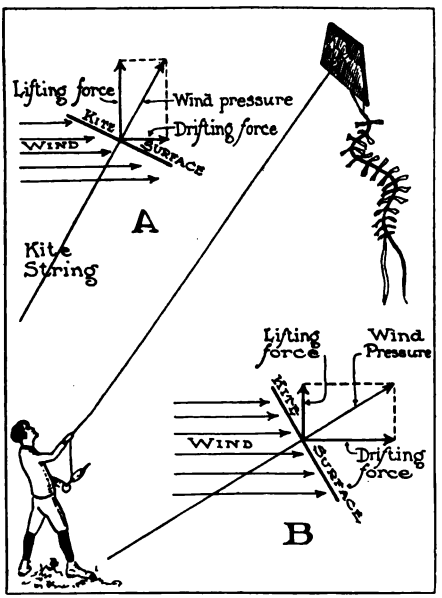
Experiment. — To show centrifugal force.

Materials: Pail half full of water. A ball fastened to end of string.

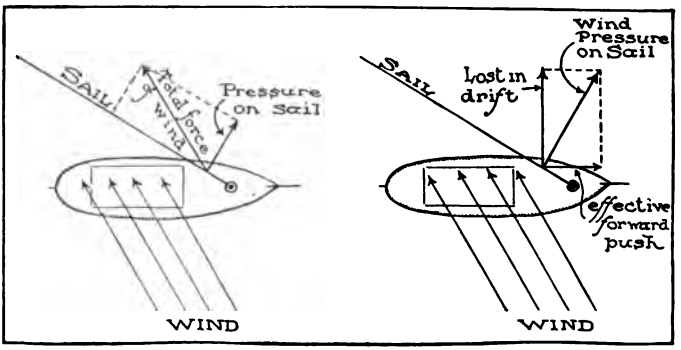
Method and Results: (*a*) Swing the pail of water rapidly overhead in a large circle. Is there a time when there is no support under the water? Does it fall out? (*b*) Whirl the ball on the string. In what directions may it go if you release it when the string is horizontal? When vertical? Make diagrams.

Conclusion: Centrifugal force is that force causing all bodies moving in a curved path to pull away from that path and to go off in a straight line. The force which pulls towards the center and keeps the whirling body in the curved path is called *centripetal force.* Explain these terms by reference to the above experiments just performed.

Pinwheels, kites, and sailboats. — Another common toy is the pinwheel. Most of us know how to cut the pinwheel, and probably everybody in the class knows that the pinwheel revolves by the force of the air striking against it, causing motion. The difficult thing in kite flying is to adjust the cord at the point of attachment so that the kite balances and will go up readily. Here again we use the force of moving air, and by fastening the kite at an angle to the direction of the wind, we cause it to rise

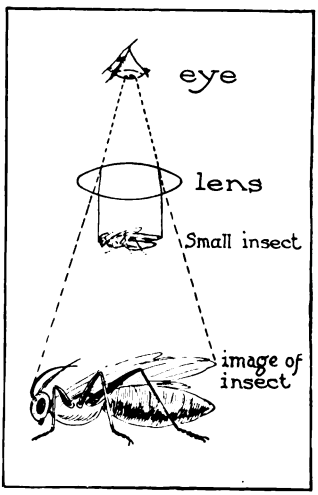


Notice that the wind produces a greater lifting force in *A* than in *B*, but that in *B* the greater part of the force of the wind causes horizontal drifting. This results from the angular adjustment of the kite surface.



When sailing into the wind, observe that only a part of the wind force presses on the sail and that only a part of the wind pressure on the sail produces a forward push on the boat.

higher in the air. A much more efficient kind is the box kite, with its double surface. This, as we can readily see, was the forerunner of the glider, which in turn preceded the airplane of the present day. Sailboats also make use of the force of the wind against the sails. An interesting project would be to work out the reason why it is possible to make a boat sail *against* the wind.

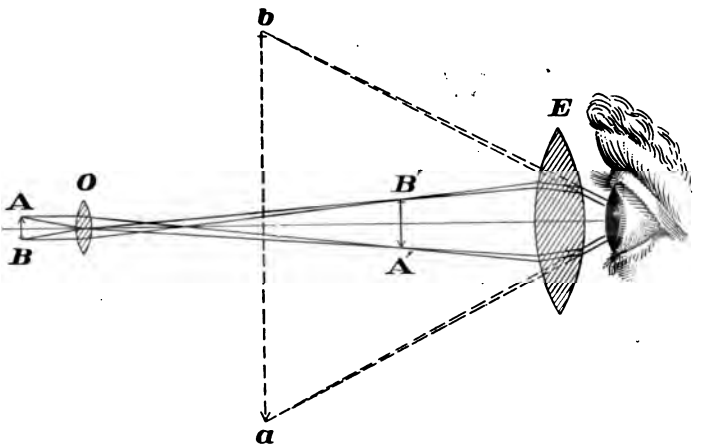


A simple microscope.

The simple microscope. — If you hold a double convex lens over a small object such as an insect or a bug, the object appears larger than it really is. The reading glass is a simple microscope consisting of a convex lens. We can even make one ourselves by blowing a small bulb at the

end of a piece of glass tubing, filling this bulb with water, and plugging the end. This is a crude microscope.

The compound microscope.— The compound microscope is a large, more complex structure. As the diagram shows, it has two sets of lenses, which make the object look larger by a double magnification, first, by a glass nearer the object,



The compound microscope makes an image *A′B′* nearer the eye than the object *AB* and then magnifies it to a still larger image *ab*.

or the *objective*, and later by a glass nearer the eye, or the *eyepiece*. While not every boy and girl can have a microscope of his own, still in most schools you will find a good compound microscope, and any good-natured science teacher will allow you to work out a project on the construction and use of the compound microscope. All sorts of new wonders are opened to those of us who can buy a small microscope for our own, as the beautiful forms of the snow crystals, the life in a drop of water, the structure of an insect's wings. Thousands of wonderful

objects lie unexplored at our doors, and can only be discovered by means of this wonderful instrument. Perhaps some day, when you study biology, you will learn more about it and its uses.

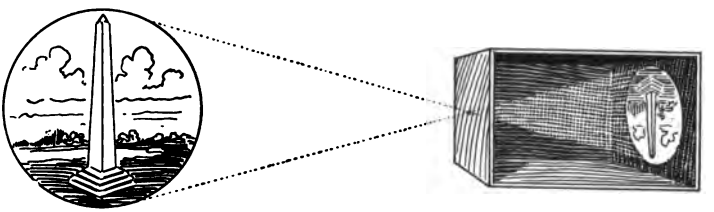
1. Picture of a bare house.

2. The same house with a setting of grounds and foliage.

3. The same house from another viewpoint. A charming picture.

Photography. — Probably one of the most fascinating hobbies that any boy or girl can have is that of photography. Not only does it help us to understand the practical use of the camera and its accessories, but it also helps us to understand better the artistic value of objects in nature. The accompanying pictures of a farmhouse illustrate very well what is meant by composition and balance. A close view (No. 1) shows the house without grounds or shrubbery. It is an example of poor composition although it has good balance of strong light and strong dark. The second is a better

picture than the first. The house at the left is balanced by the road leading to the right, but as no particular object of interest is shown at the right the picture has poor composition. In the third picture the garden path with its border of shrubs and flowers leads you unconsciously right to the door of the house. There is balance of strong light and strong dark with intermediate tones as well. By making a study of photographs you can easily learn what it is that gives them artistic value. Photography gives us a new interest in that we can picture for all time birds, wild animals, and our



Explain why the image is inverted.

favorite haunts in nature. We can make mementoes of good times together with our friends, and what makes a better Christmas present than a card which brings up some pleasant memory of summer doings? You can use photographs to illustrate your science notebooks instead of drawings, if you so desire, and many a boy and girl have made the cost of the camera several times over by taking photographs and selling them.

A pinhole camera. — The simplest camera is one which any ten-year-old boy or girl can easily make. It is a box of any convenient size, say about five inches square and three inches deep. It must have a cover which slides down over the box for a depth of at least one inch. The

interior must be painted black, and absolutely light tight. By following these directions you can make a good camera.

Cut a hole one half inch in diameter in the middle of one side or end of the box. On the inside of the box paste over the hole a piece of tinfoil. In this tinfoil you will make your pinhole. The success of your picture depends on the care with which you make this hole. The best results are obtained when the diameter of the pinhole is in proportion to the square root of the distance from the pinhole to the plate.[1] Paste cardboard strips on the inside of cover to hold the sensitized plate.

The exposure, depending on the light, should be from ten to twenty minutes. The picture is made on a glass plate which is held in place by narrow strips of cardboard glued in along the vertical edges of the plate. This plate is to be put into the camera while in a dark room. Of course, the pinhole should be kept covered until you reach the object you wish to photograph and covered again after the picture is taken.

Camera lenses and their use. — There are two types of lenses used, a single lens, found in most cheap cameras, and a lens tube with a double combination of glasses in it which may be of long focus. There is also a wide angle lens of short focus, which is excellent for working indoors. We also have the telephoto lens, which is used for long distance work, and is excellent for photographing birds, and other forms of wild life.

[1] Use the following formula:

$$\text{Diameter of pinhole} = K\sqrt{\text{Distance of plate from pinhole}}$$

$$K = .0008$$

This diameter may be measured by some machinist or science instructor who has a micrometer caliper, who can measure a needle of the right diameter, so you can make the hole just the size of the needle.

Having obtained a needle of the right diameter, do not force it all at once into the tinfoil, but work it slowly, putting pressure first on the one side, and then on the other so as not to stretch the foil when pushing the needle into the hole. When you have made the hole, be sure to smooth off the edges, as a clear picture cannot be made unless you have a clean cut hole.

What is a negative? — The picture is taken upon a glass plate or celluloid film covered with a coating of gelatine and silver bromide, or some other silver salt. Light falling on this silver compound causes a change in its composition,

Which of these two pictures is the *negative?* Which the *positive?*

so that when it is put into a developer containing certain chemicals which complete the change and make it permanent, we have a *negative* as a result. This negative gives the light values in black and white, but just the opposite of what they were in the objects photographed and just the opposite of what we have in a *positive*, or completed print. A study of the accompanying figure will show this very clearly.

Experiment. To show the processes of printing, developing, and fixing a picture.

Materials: Three small glass or enamel trays. One large tray. Printing frame with glass. Film or glass negatives. Azo or Velox paper. Developing powders and hypo. A ruby light or dimly lighted room. A strong light for printing.

Method: Work with some one who is experienced in making pictures at first. Learn from him how to do the various operations. Write a complete report of the processes and the reasons for them as learned from study. Mount a specimen print which you make yourself.

How to make a picture. — In taking a picture, we should bear in mind the following points: (1) We wish to have a pleasing composition. Try to get good balance in your picture. Focus on the principal thing to be photographed. (2) Have good light, and if possible, have the light come from behind the camera. Do not have much light and shadow, except in landscapes. Do not take a picture directly in the sun unless you shade the lens of the camera. (3) Be sure that the opening in your lens is the right size for the amount of light. This is easily determined by a study of the directions that come with any camera. You will learn to know your own lens and how to use it after you have worked with it for a time. (4) Be sure that you use an unexposed plate or film. Many pictures are spoiled by double exposures. The best way is to write on your plate holder or film each time when you take a picture. (5) Be sure to make an exposure of the proper length. Too long an exposure is as bad as too short an exposure. The camera must not be allowed to move, even in the instantaneous exposure. If you take a snapshot be sure that the image of the object you wish to take is in the finder when you snap the shutter.

Printing. — Boys and girls should learn to print their

own pictures rather than send them to a photographer, for it is easy, and a fascinating pastime. Papers are of two types, those printed by artificial light and those printed by sunlight; the latter require more time and a dark room. Blue printing paper is one form of sun printing paper, which is much cheaper and easier to handle, since we merely have to print from a negative, and then wash in cold water. Chemicals for printing and developing can be found in any good photographic shop and directions for their use in any good manual.

Enlarging. — If you have a particularly good picture, you may wish to enlarge it. This can be done by making a positive image or picture by allowing rays of light to pass through a negative, then through a lens which is focused on a sheet of sensitive bromide paper. The size of the enlargement will depend on the distance of the lens from the sheet. It is not difficult to enlarge if one has a room which can be darkened, and has a little ingenuity so that he can make a frame to hold the bromide paper. Enlargements are much more artistic because of their softer tone, and make excellent presents.

Other uses of lenses. — We are all familiar with the use of the opera glass and field glass. A good pair of field glasses apparently decreases the distance of the object looked at to one eighth of the real distance. A four-inch telescope may make an object appear one three-hundredth of its distance. In the telescope, one lens is used to make an image of the distant object, and the second lens, the eyepiece, is used as a simple microscope which magnifies this image. If you can get the use of a good field glass or small telescope, look at the moon in its different phases. You will find it a most interesting object for

observation. An evening with the telescope is an experience that few boys and girls will forget.

The stars. — Even without a telescope, the heavens present a wonderful opportunity for observation to those who are interested in the distant parts of our universe. A glance at the sky makes one think he can see myriads of stars, but in reality, on an average one can rarely see more than from two to three thousand stars while standing in one place, but by the use of a large telescope, millions of stars are found. Astronomers tell us that each one of these stars is like our sun, a huge, white-hot ball, and that many of them are very much larger than our sun. They appear very tiny because of their great distance. When we realize that the nearest of these stars (Alpha Centauri) is 25,000,000,000,000 miles away, so far that it takes about four and one third years for its light to reach us, we are lost in wonderment. And when we also know that another star (Arcturus) is 950,000,000,000,000 miles away, and that it takes one hundred sixty years for its light to reach us, we are

Yerkes telescope of University of Chicago, one of the largest in the United States.

still more amazed. It will help you to get some idea of the velocity of light when you think that as you have taken five steps across an ordinary room, light has traveled a distance equal to about twenty times the circumference of the earth.

The North Star. — One star which has guided many travelers is the North Polar Star (Polaris). When we see it, let us remember that the light which enters our eyes left that star about forty-seven years ago. Since this star is practically in line with the axis of the earth, and all other stars keep the same relative positions, with respect to the North Star, there is during the rotation of the earth each twenty-four hours an apparent rotation of all of the other stars in the sky about Polaris as a center. This fact makes it of exceptional value to the traveler.

The Large Dipper. — One of the most conspicuous star groups or constellations is the Large Dipper, or Great Bear, as it is sometimes called. If you are just learning to locate some of the more prominent stars and star groups, the Great Dipper is one you should locate first. From that you can find the North Star (Polaris) and then work out to other groups. If you will examine the diagram, you will find that a line drawn from the two stars at the end of the Dipper points directly toward Polaris, hence, they are called the "Pointers."

Which two stars are the "Pointers"?

Other star groups. — Polaris is the end star in the handle of the Little Dipper, or Small Bear. This can easily be found. Except in the region very near the North Star, some stars will be visible at certain hours of the night and not visible at others. It is an excellent plan to get some older person to show you how to use a star map, and then try to see how many new constellations you can identify. The "Guide to Nature" and the "Scientific American" have a star map each month, which will show you the time of evening to look for certain constellations. No more fascinating study can be found than that of elementary astronomy, and learning to know the constellations will give you a start in astronomy.

Our relation to the stars. — You have obtained in your geography some knowledge of the relation of our earth to the other heavenly bodies. You remember that there are eight of these bodies which travel around the sun, the earth being one of the eight. These bodies are called planets. They do not give out light of their own, but they do reflect sunlight, and appear as brilliant stars. They are never visible except in morning or evening, and are therefore called morning stars and evening stars. As we have just learned, they are not true stars, because true stars shine by their own light. The names of these planets, in order according to their nearness to the sun, and the length of their year (or the time to go around the sun), are shown in the following table:

Mercury	88 days	Jupiter	12 years
Venus	225 "	Saturn	29 "
Earth	365 "	Uranus	84 "
Mars	687 "	Neptune	165 "

Some of these planets, such as the Earth, Jupiter, and Mars, have moons which in turn revolve around them. These simply reflect sunlight, and do not give any light themselves. All of these moons, planets, and the sun together make up a small heavenly group which we call the *Solar System.* You may think the word *small* used inadvisedly. It is a large system when compared with the size of the earth, but compared with the size of the other systems and the vast expanse of the universe which we look into on a clear night, it is absolutely insignificant. It is reasonable to believe that each of the millions of stars in the sky has its own family of planets and moons, just as our sun has, but since these are so far away and have no light of their own, they are invisible to us.

Relative sizes of planets, sun, and moon.

Shooting stars. — We have all seen the burst of stars which comes from the explosion of a beautiful rocket, and indeed we have sometimes mistaken the light from a small toy balloon for that of a star. It is not strange that some people have been deceived by so-called "shooting stars" and thought that stars were actually falling. Such, however, is not the case. There are throughout the space which surrounds the earth and other planets

countless numbers of small bodies which are moving at a speed almost one hundred times as swift as that of a rifle bullet, but since there is no air, there is no resistance to these bodies, and they cannot be seen. If any of them going at this rate of speed reach the upper air they become hot because of the friction and soon begin to glow so that they appear as objects which are on fire. Since the earth attracts them, they fall toward it, usually reaching the earth as dust. Sometimes, however, a very large meteor plunges into the earth, and when we dig it up, we find it to be a mass of rock looking not unlike iron.

A shooting star.

Home and community. — All through the book we have tried to show how science touches our everyday life. Only a few of the many home pleasures have been suggested here, for much of your pleasure will be had in the companionship of others. Hiking, fishing, insect collecting, camping, boating, and bathing are all pleasures that others must share with you to be really fun. So we will leave the discussion of these to your project making and to the later treatment of community life. The purpose of the next book will be to show you how intimately science is connected with the lives of those who live together as citizens in the community. It is hoped that the book just being finished may help to make you better and more useful members of your own family. The next book will help to make you more useful and efficient citizens in your own community.

The last score card. — After you have finished this card you are to take all of the completed cards and copy

SCORE CARD OF OUTDOOR RECREATIONS (FOR GIRLS)

	Score	
	Perfect Score	My Score
Have set up (5) and can play *well* (5) one of the games mentioned in Chapter XXV	10	
Can play *well* tennis, croquet, or beanbags	5	
Collect flowers and can identify at least 20 varieties	10	
Collect insects and have specimens of at least six orders	5	
Make photographs (5), develop and print my own pictures (5)	10	
Belong to Hiking Club or Girl Scouts — can walk at least ten miles in a day without feeling tired	5	
Can pick out North Star and identify at least three constellations	5	
Total	50	

SCORE CARD OF OUTDOOR RECREATIONS (FOR BOYS)

	Score	
	Perfect Score	My Score
Have set out (5) and can play *well* (5) at least one game mentioned in Chapter XXV	10	
Have made a kite that will fly and stay up in a moderate wind *or*		
Have made a model airplane that will fly at least 100 feet	10	
Have made a sailboat that will sail against the wind	5	
Collect insects and have specimens of at least six orders	5	
Make photographs (5), develop and print my own pictures (5)	10	
Belong to Hiking Club or Boy Scouts, can walk at least twenty miles a day without feeling tired	5	
Can pick out North Star and identify at least three constellations	5	
Total	50	

in the column marked "My final real score" in the long preliminary score card, the totals for each of the smaller cards at the ends of certain of the chapters. It will be interesting to compare your final score with the guess you made at the beginning. Were you too high in your first estimate? And do you really think you have improved conditions somewhat as a result of this study of science? If so, then this book will have accomplished its purpose.

REFERENCE BOOKS

Adams, *Harper's Outdoor Handy Book*, pages 120–143 (Kites). Harper and Brothers.

Baker, *Boy's First and Second Books of Inventions*. McClure, Phillips, and Company.

Beard, *Outdoor Handy Book*, pages 46–94 (Kites). Charles Scribner's Sons.

Book of Knowledge, Project References for all above.

Bodmer, *Book of Wonders*. Project references. Presbrey Syndicate.

Ball, *Starland* (Last chapter, although entire book is interesting reading). Ginn and Company.

Campbell, *American Girl's Home Book of Work and Play*, pages 175–183 (Archery). G. P. Putnam and Sons.

Cassell, *Complete Book of Sports and Pastimes*, pages 239–244. Cassell and Company.

Clark, *Introduction to Science*, Chapter XXVIII (Photography). American Book Company.

Downing, *A Field and Laboratory Guide in Physical Nature-study*. University of Chicago Press.

Fall, *Science for Beginners*, Chapter XXVIII. World Book Company.

Hodgdon, *Elementary General Science*, Chapter XII (Stars, etc.). Hinds, Haydcn, and Eldridge.

How to Make Good Pictures. Eastman Kodak Company, Rochester, N. Y.

Lynde, *Physics of the Household*, Chapter XXVI. The Macmillan Company.

Miller, *Outdoor Sports*. Doubleday, Page and Company.

Miller, *Outdoor Work*. Doubleday, Page and Company.

Smith and Jewett, *Introduction to Science*. The Macmillan Company.

Thompson, *Boy's Book of Sports*, pages 177–196. The Century Company.

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